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COMPUTER SIMULATION STUDY OF THE JOINT DEPLOYMENT OF THE 23RD WING AND 82ND AIRBORNE DIVISION FROM POPE AIR FORCE BASE

THESIS

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THESIS

Presented to the Faculty of the School of Logistics and
Acquisition Management
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Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

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Preface

The purpose of this study was to develop a computer simulation model that could help determine the resource requirements of a simultaneous deployment of Army and Air Force elements from Pope AFB. This model is needed to augment a feasibility study of the Pope AFB system that was recently completed by the Air Mobility Command (AMC).

While much of the expertise used in modeling the system came from transporters with the 3rd Aerial Port Squadron, planners at AMC, and documentation of lessons learned during past large-scale deployments, we also drew heavily from our own substantial experience in mobility operations. Although this study produced only a partial model, it's opened doors for further research. The completed segments show the sensitivities of the actual system and lay the foundation for development of a generalized resource sizing model.

During the long hours spent on model formulation, coding, and debugging, as well as the actual writing of this thesis, we had a great deal of help from others. First and foremost, we would like to thank our wives, Laura Prechtel and Patti Wingreen, for their patience, understanding, and support throughout this period. A word of thanks is also due to Lt Col Dave Diener and Maj Judy Ford, our thesis advisors, for the direction and assistance they provided.

Brad Prechtel and Mark S. Wingreen

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Abstract

This thesis produced a model of the Army airdrop segment of the Pope AFB deployment system. The original intent was to model the entire Pope AFB deployment system and simulate the simultaneous airland deployment of the 23rd Wing and airdrop deployment of the 82nd Airborne Division; however, time constraints and incomplete data forced a reduction in scope. The study provides an excellent foundation for further research into the use of simulation to develop a generalized deployment resource sizing model.

The airdrop segment of the system was modeled using information obtained from the researchers' personal observations of the system, the expertise of personnel who work within the system, and documentation of the problems and lessons learned during previous large-scale deployments. The parameters determined to significantly affect system performance were modeled; those that didn't affect system performance were not. The conceptual model was validated through comparison of the conceptual model and the actual system with air transportation experts assigned to Pope AFB. The coded model was then verified through 1) numerous runs in test mode where the researchers iteratively refined the coded logic and 2) sensitivity analysis that determined the model behaved as expected by experts within the Pope system.

COMPUTER SIMULATION STUDY OF THE JOINT DEPLOYMENT OF THE 23RD WING AND 82ND AIRBORNE DIVISION FROM POPE AIR FORCE BASE

I. Introduction

Background

With the recent decline of the Soviet threat and the subsequent downsizing and restructuring of the United States military, rapid global force projection has become a cornerstone of U.S. National Security policy. The new National Military Strategy outlines changing world realities in which the U.S. defense establishment faces a less stable and less predictable threat at a time when defense budgets are being reduced significantly. In this environment, which stresses flexibility and efficiency of operations, military commanders will rely more and more on U.S.-based forces to rapidly respond to contingencies worldwide (CCW, 1992: 1-1).

The New Air Force Composite Wings. In response to this new National Military Strategy, the Air Force has developed two composite wings and is in the process of designing a third. The composite wings combine dissimilar aircraft, such as fighters, refuelers, and bombers, which offer different air combat capabilities, into a single wing controlled by one "boss" and capable of providing more

firepower and a broader spectrum of capabilities than a single traditional wing alone can provide. The 366th Wing, located at Mountain Home AFB, ID, was designed for air intervention and includes F-16, F-15C, and F-15E fighter aircraft, E-3A airborne warning and control aircraft, KC-135 refueler aircraft, and will add either B-52 or B-1B bombers. The 23rd Wing, located at Pope AFB, NC, contains 16 C-130 transports and 24 A-10 and OA-10 fighter aircraft, and is currently adding F-16 fighters. The 23rd Wing will provide the Army's 82nd Airborne Division (collocated with Pope AFB at Fort Bragg, NC) with tactical airlift, close air support, and battlefield air interdiction. A third composite wing, fashioned after the 23rd Wing, is projected for Moody AFB, GA and will support the Army's 24th Infantry Division based at Fort Stewart, GA. (Bird, 1992:14).

The concept behind the composite wings is, in part, to have available a logistically lightweight, self-contained fighting force that can get to the battlefield quickly and provide a variety of air power capabilities immediately upon arrival (Bird, 1992:18). The composite fighting force is more easily tailored to the requirements of a specific military operation and thus more responsive to short notice, low-intensity contingencies than a similar force drawn from a number of geographically and organizationally separate air wings (CCW, 1992: 1-2). This assertion is intuitively appealing for a number of reasons. First, since all

deploying air forces will be working for the same wing commander, "turf battles" should be minimal. A number of different wings won't be vying for support of their own parochial interests and a more concerted deployment effort should result. Coordination of deployment actions will also be vastly simplified. Finally, the logistics tail, which is the support equipment and personnel required to operate deployed forces, should be somewhat reduced since one deploying wing will tend to better coordinate support requirements than a number of dissimilar wings could.

Both the 23rd Wing and the projected Moody AFB wing are what have been termed airland operations wings (ALOWs) whose primary mission is to deploy with and support Army ground forces. The wings are designed to support a division-sized force and are capable of both stand alone and integrated air/ground operations with up to a corps-sized Army element. The concept of operations for these ALOWs is referred to as the "Integrated Operations Concept for Corps Element and Airland Operations Wing", or more simply "CCW" (CCW, 1992: iii). The CCW, which is still in a developmental stage, is discussed below.

<u>The CCW and the 23rd Wing/82nd Airborne Division Affiliation</u>. The Air Force wing/Army division team envisioned in the CCW will provide the nation with a highly mobile, yet complete, joint force capable of rapidly deploying into a hostile environment, gaining an initial

foothold, and operating effectively as a self-contained unit until augmented by more traditional service elements. The Army and Air Force units that make up the team provide pre-tailored, rapid-response force packages that will be the first forces deployed in a contingency. The missions envisioned for the CCW team include "forcible entry/force projection, air assault, base defense, and non-combatant evacuation operations in a non-permissive environment" (CCW, 1992: iii, 4-2). The affiliation between Air Force ALOWs and Army rapid response units will be maintained during both peacetime and contingency operations so the units will be familiar with each other's capabilities. The Air Force Chief of Staff, General McPeak, describes the wing/division relationship this way:

> Together this team will comprise the nation's premier forcible entry capability for the future. The wing will not be chained to a division--the joint commander in a theater can break the wing loose, if absolutely necessary. But make no mistake, the idea is to form an air-ground team. The day-to-day teamwork between the wing and the division will overcome a problem that has always concerned me. These units will not be strangers meeting each other for the first time on the way to do some incredibly difficult combat task. They will work together, get to know each other, and give new meaning to the idea of joint teamwork. (Policy Letter, 1992)

The activation of the 23rd Wing (an ALOW) and establishment of the CCW concept significantly alters the long-standing relationship between the Army's Fort Bragg and the Air Force's Pope AFB. Traditionally, the overriding

mission of the Air Force at Pope AFB was to rapidly deploy the 82nd Airborne Division, which was usually among the first echelon of ground forces deployed in response to a contingency. Now, however, the Air Force has some very significant deployment requirements of its own at Pope. This change has caused concern among Army leadership that Pope AFB may currently not be able to deploy the 82nd Airborne Division in a timely manner (Betsch, 1992: 1). As a result, personnel at Forces Command (FORSCOM), Transportation Command (TRANSCOM), Air Combat Command (ACC), Air Mobility Command (AMC), and the 23rd Wing have been studying the feasibility of a large-scale, joint deployment of the forces specified in the CCW from Pope AFB.

The Pope AFB Deployment Environment. The Pope AFB deployment environment is different than that currently found at any other Air Force base. First, the main unit that processes and deploys from Pope is a rapid response Army unit as already mentioned. With the addition of the 23rd Wing's mobility requirements, the base must now simultaneously conduct two similar, but different, deployment operations. The 82nd Airborne Division, like all Army units, deploys under the guidelines of AFR 76-6, "Movement of Units On Air Force Aircraft," while the 23rd Wing, like all Air Force units deploying from home station, deploys under the guidelines of AFR 28-4, "USAF Mobility Planning." Differences between these two operations range

from types of structure to paperwork requirements, but for the purposes of this study, one of the most important points is that they are different, geographically separate operations.

Another important element that separates the Pope AFB operation from the mobility operations at other Air Force bases is the type of equipment that the 82nd Airborne Division deploys during an airdrop deployment. In this type of deployment, a number of pieces of equipment weighing in excess of 10,000 pounds each are routinely configured on airdrop platforms (basically a pallet designed to be dropped from an airborne aircraft), which are too large to be moved with a 10K forklift. This fact makes the handling requirements for this equipment unlike that found at any other Air Force base engaged in normal Air Force mobility operations. These special features, as well as other significant aspects of the Pope AFB deployment operation are discussed in greater depth in chapter 2.

Army planners' current reservations with the ability of the Pope AFB operation and infrastructure to support their needs are caused not only by the addition of the 23rd Wing's requirements, but also by experience with a number of past deployments. There have been several large-scale deployments from Pope's airfield in the past where the base's infrastructure was severely strained. Deployments to Panama and Southwest Asia, as well as mobility and

Operational Readiness Inspection (ORI) exercises, all highlighted the limitations of the Pope AFB Army deployment processing and upload area, or "Green Ramp" as it is more commonly referred to, during surge aircraft outload times (Joint, 1990:83-89). With the addition of the 23rd Wing's requirements, future large-scale deployments can be expected to cause even more problems.

General Issue

The concern among Army leaders about the addition of Air Force deployment requirements at Pope AFB, coupled with overcrowding problems that have occurred during past large-scale deployments from the base, has prompted both Army and Air Force planners to carefully evaluate Pope AFB's assigned assets and infrastructure to determine whether it can support a simultaneous deployment of the 23rd Wing and the 82nd Airborne Division. An ACC study indicated that a simultaneous deployment was feasible from an airlift perspective while a joint 23rd Wing/XVIII Airborne Corps study concluded that the deployment was "do-able" from an air transportation support position. The Joint Deployment Study group felt the issue would be best addressed through a series of local exercises designed to test the effectiveness of joint 23rd Wing/82nd Airborne Division deployments (Plans, 1992: 1-2).

The 23rd Wing has not yet participated in any large-scale deployment exercises with the 82nd Airborne Division, but the first is planned for early calendar year 1994 (Head, 5 October 1992). The exercise will follow the scenario of an airland deployment of the 23rd Wing and an airdrop deployment of one Deployment Ready Brigade (DRB) of the 82nd Airborne Division (Eisenberg, 2 October 1992). The magnitude of the planned exercise can be seen in the number of aircraft loads scheduled to be processed and loaded -- 133 aircraft loads, or chalks, on 14 C-5 and 119 C-141 transport aircraft in a two-day time period. The deploying units, along with total equipment weight and the number of deploying personnel are summarized in Table 1 below.

TABLE 1

EQUIPMENT AND PERSONNEL TO DEPLOY
UNDER THE SIMULATED SCENARIO

	Cargo (Short Tons)			
Unit	Airland	Airdrop	Passengers	Paratroopers
23 Wg	572.4	0	748	0
82 ABN Div	1358.5	1067.2	531	2244
JSOC	92	0	104	0

Note: 1 Short Ton = 2000 lbs.

The Transportation Plans and Programs department at AMC and the Air Land Sea Applications Center have been deeply involved in a number of studies to determine deployment requirements, constraints, and identify possible problem areas and have determined that a detailed computer model capable of simulating the simultaneous deployment of the 23rd Wing and the 82nd Airborne Division would significantly aid in problem identification. Most of the required input data was collected through a number of time studies by personnel assigned to the 3rd Aerial Port Squadron (3 APS) at Pope AFB. Personnel at 3 APS also conducted a preliminary, hand-calculated simulation of the planned deployment; however, AMC determined they currently lack the "in-house" resources to construct a computer model with the required level of detail (Head, 5 October 1992).

Specific Problem

This study models the Pope AFB deployment system and simulates alternative deployment scenarios to determine feasibility, identify potential deployment problem areas, and evaluate possible solutions. In particular, the study seeks to answer two questions. First, what are the requirements in terms of ramp space, facilities, equipment, and personnel to support a simultaneous deployment of Army and Air Force units from Pope AFB? Second, are enough of

those resources required to successfully support such a deployment currently available at Pope AFB?

Research Objectives

To be successful, this research must satisfy the following objectives:

1) Identify the significant causal, background, and response variables within the Pope AFB deployment processing and loading operation and determine how they interact.

2) Identify the constraints inherent to the 23rd Wing, the 82nd Airborne Division, and the Pope AFB environment.

3) Determine whether an existing model can be modified and used to study the deployment problem from a "micro" or base level.

4) In the absence of a suitable existing model, construct a new computer model, incorporating the information from 1 and 2 above, that accurately represents the Pope AFB deployment operation.

5) Identify potential deployment problem areas by simulating the simultaneous airland deployment of the 23rd Wing and the airdrop deployment of one DRB from the 82nd Airborne Division.

6) Determine possible solutions through "what if" simulation experiments.

Scope/Limitations

The scope of this research study is restricted to joint deployment operations at Pope AFB involving the 23rd Wing and the 82nd Airborne Division. The study does not consider any unit actions, such as cargo preparation, taken prior to cargo or passenger delivery to the deployment processing area nor does it consider enroute operations or beddown and employment at deployed locations. It also does not consider any operations not related to the deployment, such as arriving channel, or regularly scheduled, airlift missions.

Since simulation is not an optimization method, the model will not provide the optimal mix of personnel, equipment, and holding space. The model can only be used to evaluate alternatives from which to choose and to determine resource/policy sensitivities by running different combinations of constraint variables.

Overview

The second chapter of this thesis examines the literature currently available on Air Force and airlift doctrine, general deployment operations, and deployment operations specific to Pope AFB. The purpose is to provide an understanding of the Pope AFB deployment system and some of the limitations of that system. The review includes numerous interviews and unpublished sources such as past Pope AFB ORI reports, briefings on the Pope deployment infrastructure, and the "Joint Committee Report on Operation

DESERT SHIELD," the international response to the Iraqi invasion of Kuwait. This chapter also reviews the literature on past simulation studies and general simulation modeling techniques.

The third chapter discusses model development in depth. The chapter begins with a detailed explanation of the assumptions that were made in modeling the Pope AFB deployment system. Next, the parameters and variables from the actual system that are included in the model are listed and defined and the methods for data collection and input to the model are explained. At the same time, potential users of the model are instructed how to construct the trace files which input data to the model and how to run the model file.

The fourth chapter focuses on validation and verification efforts. Verification for the airdrop model segment was completed, whereas validation is incomplete. The chapter closes by identifying the limitations of the joint deployment model.

The fifth chapter presents recommendations for future research. The most pressing of these is the need for a comprehensive time study of the various increment processing times. Suggestions for completing the model and then making it more "user friendly" and generalizing it for use in other deployment scenarios are also provided.

Additional supporting material is included in a number of appendices at the end of the text. A few of these

appendices warrant mention here. Appendices A and B provide a glossary of technical terms and a glossary of acronyms respectively. Also, Appendix C provides a copy of the communicative model of the Pope AFB deployment system and Appendix D provides the computerized simulation model.

II. Literature Review

Introduction

This literature review documents information used in developing a computer simulation model for analyzing joint 23rd Air Wing and 82nd Airborne Division deployments from Pope AFB, NC. The review focuses on the Air Force, airlift, and deployment doctrine that impacts on the Pope AFB deployment operation, essential elements of the Pope AFB deployment environment, past simulation studies dealing with similar issues, and some general modeling techniques. This search is necessary to obtain enough information to build the required system detail into the simulation model and ensure it is a valid representation of the actual Pope AFB deployment system, while avoiding any duplication of past research.

Air Force, Airlift, and Deployment Doctrine

Airlift has become a critical component of the country's military forces in recent years. As early as the Vietnam conflict, during which numerous elements of the modern airlift system were created and refined, airlift was emerging as an extremely important element of force mobility. By 1980, deployment thinking had become manifest in the concept of the mobility triad of airlift, sealift, and prepositioning in which airlift was recognized as the key element (Miller, 1988). With the recent drawdown of

U.S. forces stationed in Europe and other overseas Areas of Responsibility (AORs), the airlift mission of the U.S. Air Force has become even more important, as evidenced by this statement from current Air Force Doctrine:

> Airlift provides global reach for military forces, a capability of particular importance given the worldwide commitments and interests of the United States. Without airlift, the United States would be hard-pressed to respond to far-flung crisis situations. Viewed in this light, effective airlift becomes the backbone of deterrence, at least at the nonnuclear level. (AFM 1-1, 1992:187)

In addition to becoming more important to the nation's mobility posture, the basic nature of airlift operations has begun to change. The most significant change is that the concept of projecting force in three phases is no longer the method most likely favored by modern airlift doctrine (Miller, 1988). These three phases include moving forces first from either a main operating base in the continental United States (CONUS) or an established U.S. military installation overseas to a second main operating base in the theater of operations; then from the second main operating base to a forward operating base; and finally from the forward operating base to the final destination. This three-phase process is known as strategic deployment. Current doctrine recognizes that forces can get to a conflict more quickly if they are delivered directly to the final destination (Miller, 1988). Thus, we now have two established methods of delivering forces to a theater of

operations: strategic deployment and what is now termed strategic employment. The published aerospace doctrine states that

> Strategic employment is used to insert combat forces directly into a theater and a hostile situation, as in Operation Urgent Fury. Such employment requires support from suppression forces as well as control of the aerospace environment. Strategic deployment or redeployment, in contrast, requires no suppression support. (AFM 1-1, 1992:188)

This new deployment thinking, combined with reduced budgets, downsizing, and the current emphasis on jointness, has contributed to the formation of the Air Force's composite airland operations wings (ALOWs) and adoption of the CCW concept. This is evidenced in the mission of the combined Air Force ALOW/Army division team -- to conduct forcible entry, air assault, base defense, and non-combatant evacuation operations in a hostile environment (CCW, 1992:iii, 1-2, 4-2). All of these operations entail strategic employment of forces. To make these complex joint employment operations work, the Army and Air Force units must train together extensively in peace time (Policy Letter, 1992). Since effective strategic employment of forces requires deployment of the right forces at the right time, the initial mobilization and deployment processing actions required in a strategic employment operation are one of the areas in which extensive training between certain Air Force and Army units is a must.

The Army and Air Force mobilize and deploy using different processes which are specified in the regulations governing each service's movement. The Air Force deploys under the guidance of AFR 28-4, "USAF Mobility Planning," while the Army deploys under the joint regulation AFR 76-6/Army Field Manual 55-12, "Movement of Units in Air Force Aircraft." Each regulation has different guidelines for the preparation and loading of unit cargo and the handling of passengers. Air Force unit moves require much more documentation of cargo and passengers than do Army unit moves. AFR 28-4 also goes into much more detail about the flow of information and control of mobility operations than does AFR 76-6.

Air Force Unit Moves. Air Force mobility operations are controlled by the Mobility Control Center (MCC), which is headed by the Installation Mobility Officer (IMO) and composed of representatives from each of the major functional areas. The MCC coordinates the actions of the deploying units and the Transportation Control Unit (TCU) to ensure unit equipment and personnel are mobilized and deployed in a timely manner (AFR 28-4, 1987:MOP 1). Figure 1 shows the functional structure of a typical Air Force mobility operation. The TCU controls all transportation functions including the Sub-Motor Pool (SMP), the Air Cargo Terminal (ACT), and the Air Passenger Terminal (APT) (AFR 28-4, 1987:MOP 3). The SMP is responsible for moving

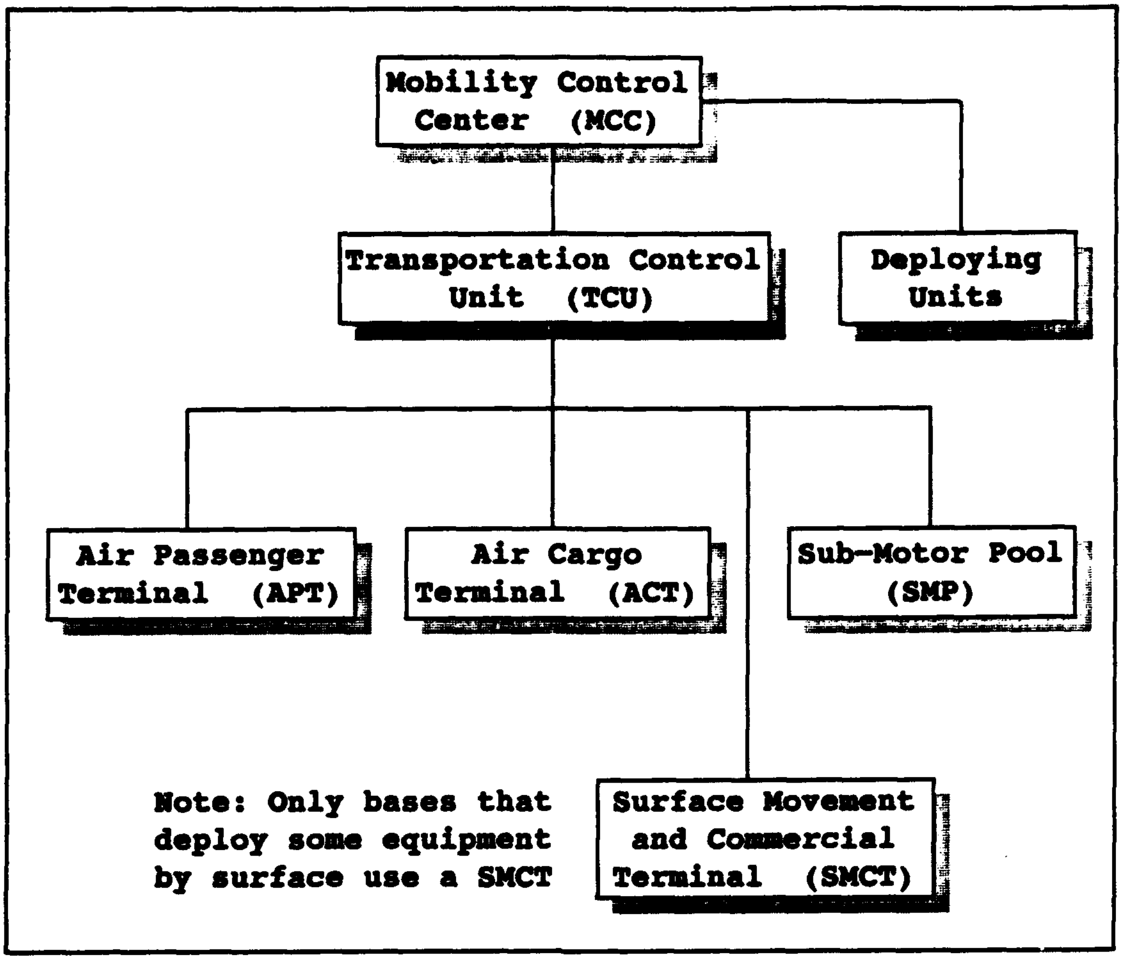

Figure 1. Functional Structure of an Air Force Mobility Operation (AFR 28-4, 1987: MOP 1, MOPS 3-6, MOP 26)

all unit cargo and passengers from the respective units to the appropriate mobility work centers and providing general vehicle support to the mobility work centers as required (AFR 28-4, 1987:MOP 6). The ACT is responsible for processing and loading unit cargo. Processing a unit's cargo involves first inspecting the cargo jointly with a unit representative and then marshaling the cargo in chalk order, which is the order in which it will be loaded aboard

the aircraft (AFR 28-4, 1987:MOP 5). Finally, the APT is responsible for processing, briefing deployment specifics to, and loading unit personnel aboard departing aircraft (AFR 28-4, 1987:MOP 4). The Manpower Processing Unit is usually co-located with the APT and assists in passenger processing by ensuring personnel are properly equipped, trained, and otherwise prepared (e.g. shots, passports, family and financial obligations met, etc.) to deploy (AFR 28-4, 1987:MOP 9).

Army and Other Non-Air Force Unit Moves. In contrast to the typical Air Force operation, Army mobility operations are controlled by the Departure Airfield Control Group (DACG). The DACG, which is roughly equivalent to the MCC and is staffed by both Army and Air Force personnel, is responsible for coordinating and controlling Army Deployments (AFR 76-6, 1989:2-2). Figure 2 shows the functional structure of a typical DACG operation. The DACG acts as the liaison between the deploying units and the Airlift Control Element (ALCE). The ALCE maintains operational control over airlift assets and personnel when the deployment operation is from a base with no organic airlift command and control element. Operational control of deploying unit equipment and/or personnel transfers to the DACG as the equipment and personnel are delivered from the units to the Alert Holding Area. In addition to accepting cargo and personnel from the deploying units, the Alert

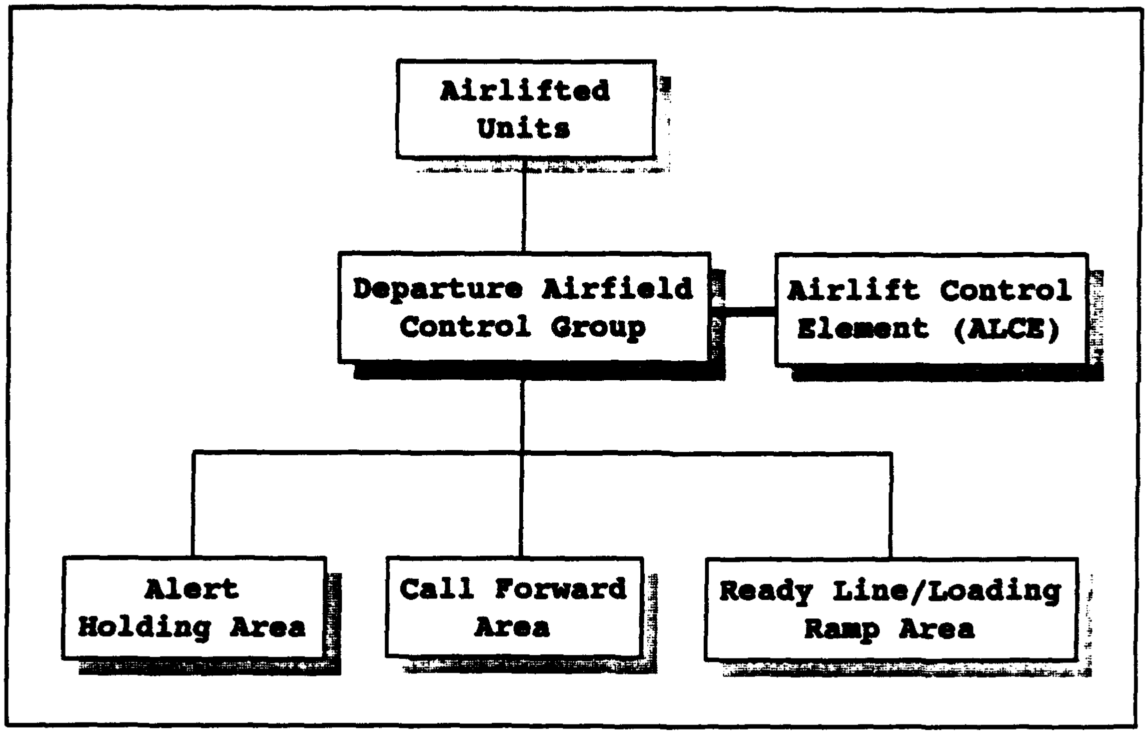

Figure 2. Functional Structure of a Departure Airfield Control Group (DACG) (AFR 76-6, 1989: 2-4)

Holding Area conducts a pre-inspection of the cargo and/or personnel and corrects any discrepancies found. The Call Forward Area conducts the Joint Inspection (JI) of cargo in which both DACG and ALCE members certify the air worthiness of the cargo. Any discrepancies noted are corrected by DACG personnel. Also, the Call Forward Area briefs deploying passengers and produces final cargo and passenger manifests. As cargo and passengers are moved to the Ready Line, operational control chops to the ALCE or other airlift control agency. In the Ready Line/Loading Ramp Area, DACG personnel load aircraft as directed by ALCE personnel (AFR 76-6, 1989:2-2 to 2-7).

The Pope AFB Deployment Environment

As previously mentioned, the Pope Air Force Base deployment environment differs from that found at almost any other Air Force base. The following discussion briefly describes some of the main features of that environment, including operations, layout and facilities, and available resources. Many of the more significant aspects of the environment are highlighted, while some of the problem areas found and improvement recommendations made by various past studies are noted. Note that since t' focus of this study is on a deployment scenario in which the Army deploys much of the 82nd Airborne Division *airdrop* as opposed to *airland*, discussion of the DACG operation is concentrated on airdrop *configured* loads. Since this discussion contains a number of specialized terms, readers unfamiliar with both strategic and mobile aerial port procedures should review the Glossary of Technical Terms at Appendix A before proceeding. A review of the communicative/conceptual model of the Pope AFB deployment system located in Appendix C may also facilitate a better understanding of the discussion that follows.

Deployment Operations. One of the most distinguishing characteristics of the Pope AFB deployment environment is that both an Air Force home station mobility machine and a DACG operation are used simultaneously. Due to the large amount of cargo and personnel that will move during future joint Army/Air Force deployments from Pope AFB, the current

system of MCC control for deploying Air Force units and DACG control for deploying Army units will be maintained (Williams, 16 December 1992). These two operations are organizationally independent of, and geographically separate from, each other. All Army cargo is inspected and marshaled at the DACG facility adjacent to Green Ramp and all Air Force cargo is inspected and marshaled at the Air Force Marshaling Yard on Silver Ramp and then loaded aboard aircraft on Blue Ramp. The location of these ramps can be seen in the layout of Pope AFB at Figure 3. Although this system requires duplication in many deployment functions, including command and control, the dual operation is necessary to avoid the bottlenecks that would result if all deploying Air Force and Army cargo were inspected and marshaled in one area. The duplication of inspection and loading operations, in particular, places a much greater load on aerial port equipment and manpower resources than would a consolidated operation.

The Air Force mobility operation works the same as mobility machines found on every other Air Force base. Cargo arrives at the ACT and is inchecked, joint inspected, marshaled in chalk order, and loaded aboard the appropriate aircraft as those aircraft arrive. Since all Air Force cargo is configured for airland missions, there are no requirements for specialized equipment or cargo handling procedures (other than explosive cargo). Rolling stock,

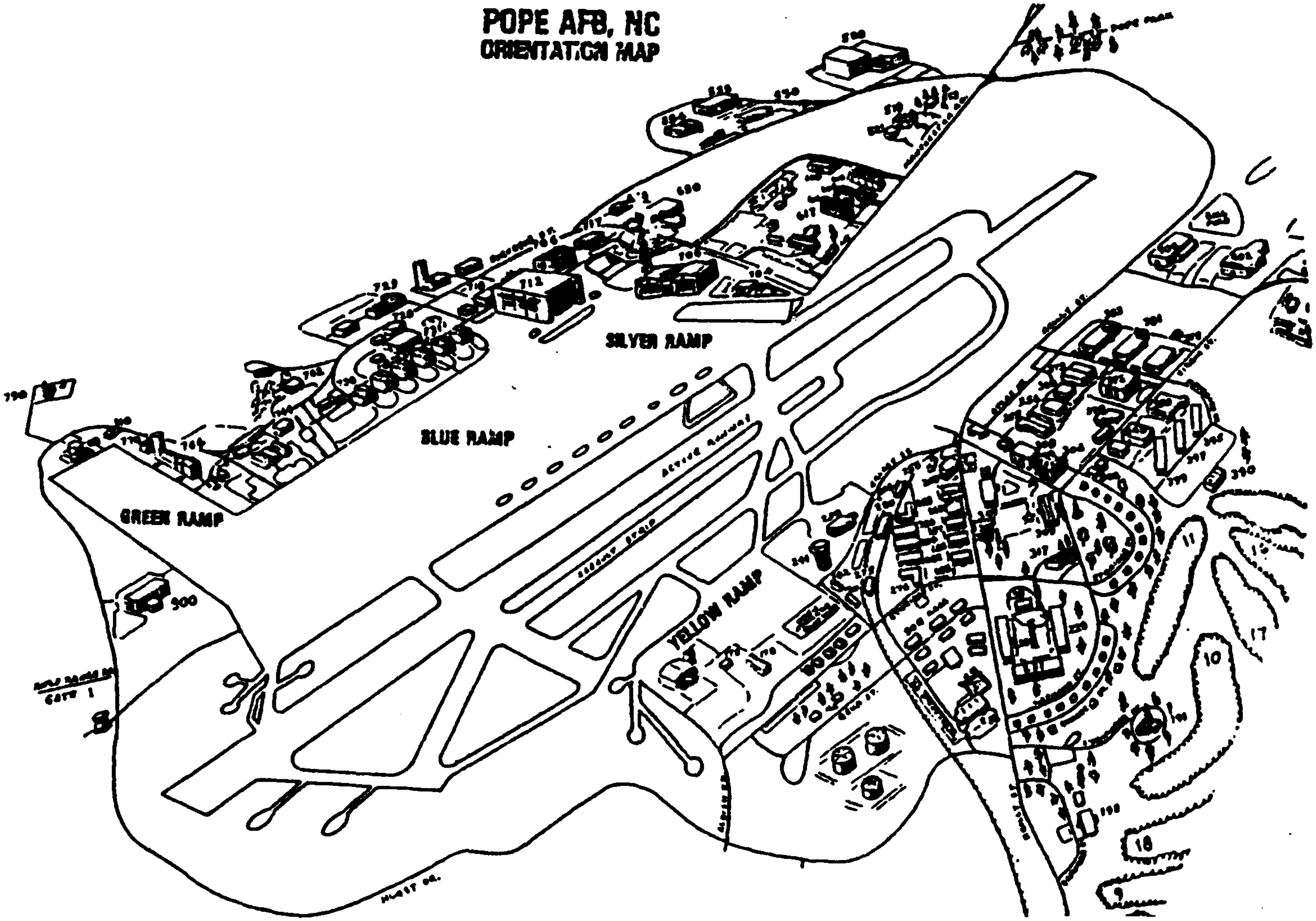

Figure 3. Layout of Pope Air Force Base

which is wheeled equipment, is either driven or, if not self-propelled, moved using a prime mover (bobtail, 1/2 Ton truck with pintle hook, tug etc.) about the marshaling yard and to the aircraft for loading. All palletized cargo weighs less than 10,000 pounds so it can easily be moved using standard 10K forklifts and stored on the ground using three-point dunnage (three 4x4s placed one at each end of the pallet and one in the middle).

In stark contrast, the Army DACG is an entirely different operation. Airland configured cargo is treated very nearly the same way airland cargo is in the Air Force mobility; however, many of the increments the 82nd Airborne Division delivers to the Call Forward Area are configured for airdrop as opposed to airland missions. The airdrop platforms used for these increment configurations cannot be stored on the ground because of their length, which is usually over 2.5 pallet positions, and/or their weight, which is usually over 10,000 pounds. The reason for this is that due to the airdrop increments length and/or weight they cannot be picked up and transported with a 10K forklift and/or loaded onto a K-Loader as can regular palletized cargo increments that are configured on standard 463L pallets. Instead, they must be downloaded from the flatbed trucks which deliver them to the scales area and loaded directly onto K-Loaders with a stationary 55-ton crane. The platforms then must be stored on either K-Loaders, highline

docks, or rollerized flatbed trailers until loaded aboard an aircraft. As a result the Army's airdrop increments are much more equipment intensive than are cargo increments configured for airland airlift missions.

<u>Layout, Facilities, and Ramp/Marshaling Space</u>. As previously stated, during a joint deployment at Pope AFB, the Air Force mobility machine will operate on Silver and Blue Ramps and the Army DACG operation will be conducted on Green Ramp. This section provides a brief description of the ramp space, facilities, and stationary equipment available at each location. This discussion of the Pope AFB infrastructure concludes with a look at some of the potential problem areas noted during past studies and some suggestions for future improvements.

<u>The 23rd Wing Mobility Machine</u>. The physical layout of the Air Force mobility machine is as shown in Figure 4. Cargo is inchecked, inspected, and marshaled on Silver Ramp and then transported to Blue Ramp for loading. The size of the marshaling yard can be varied to provide from 200 to 300 pallet positions of marshaling space (Loveland, 9 June 1993). Since no airdrop configured loads are handled at the Air Force mobility operation, there is no specialized material handling equipment located there. Passengers meanwhile are processed, briefed, and held at the APT, which is located at the Air Force Mobility Processing Center. This facility, which also houses the MCC and TCU,

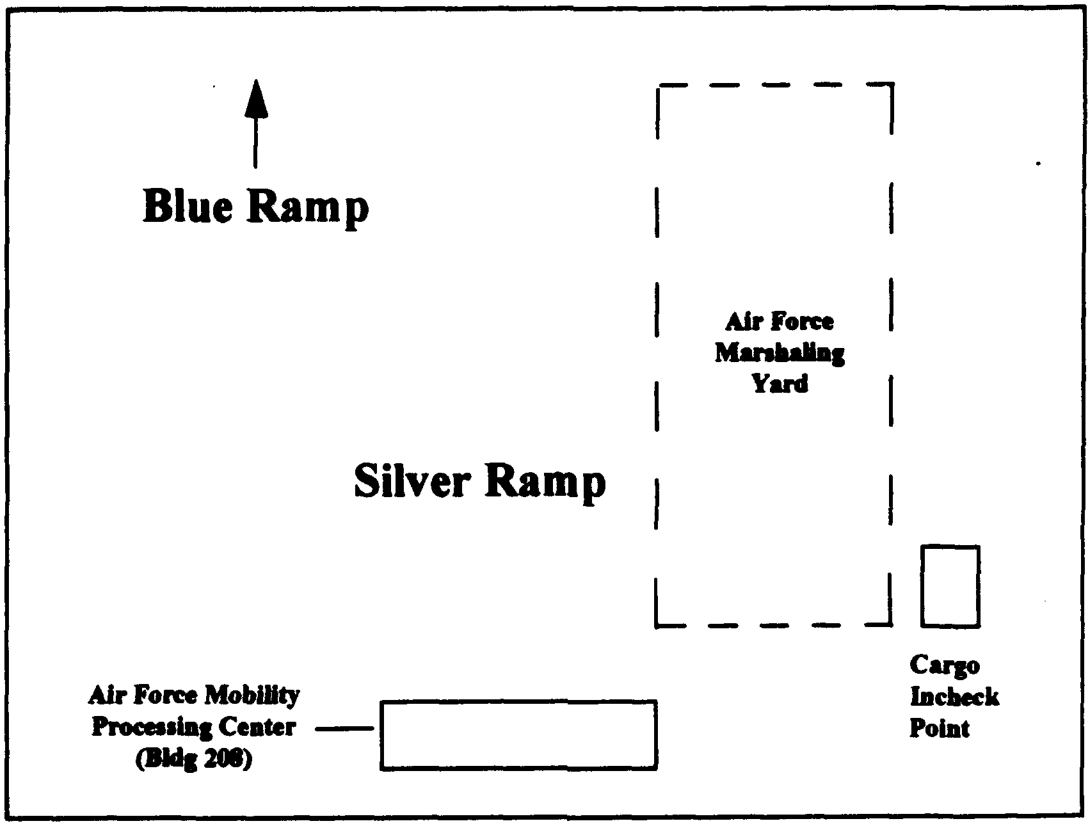

Figure 4. Layout of the 23rd Wing Mobility Machine

can accommodate approximately 200 passengers at one time (Loveland, 9 June 1993). Blue and Silver Ramps together provide parking space for up to 8 C-141s. With the 23rd Wing's aircraft flushed, capacity increases to 25 C-141 parking spots (Comstock, 1992).

<u>The DACG Operation</u>. The area in which the DACG operation is conducted is as shown in Figure 5. Arriving cargo is staged at the Alert Holding Area. Airdrop cargo is then weighed on the coal yard scale next to the crane and either staged on K-loaders in the call forward area or on one of the highline docks until aircraft load time. Storage

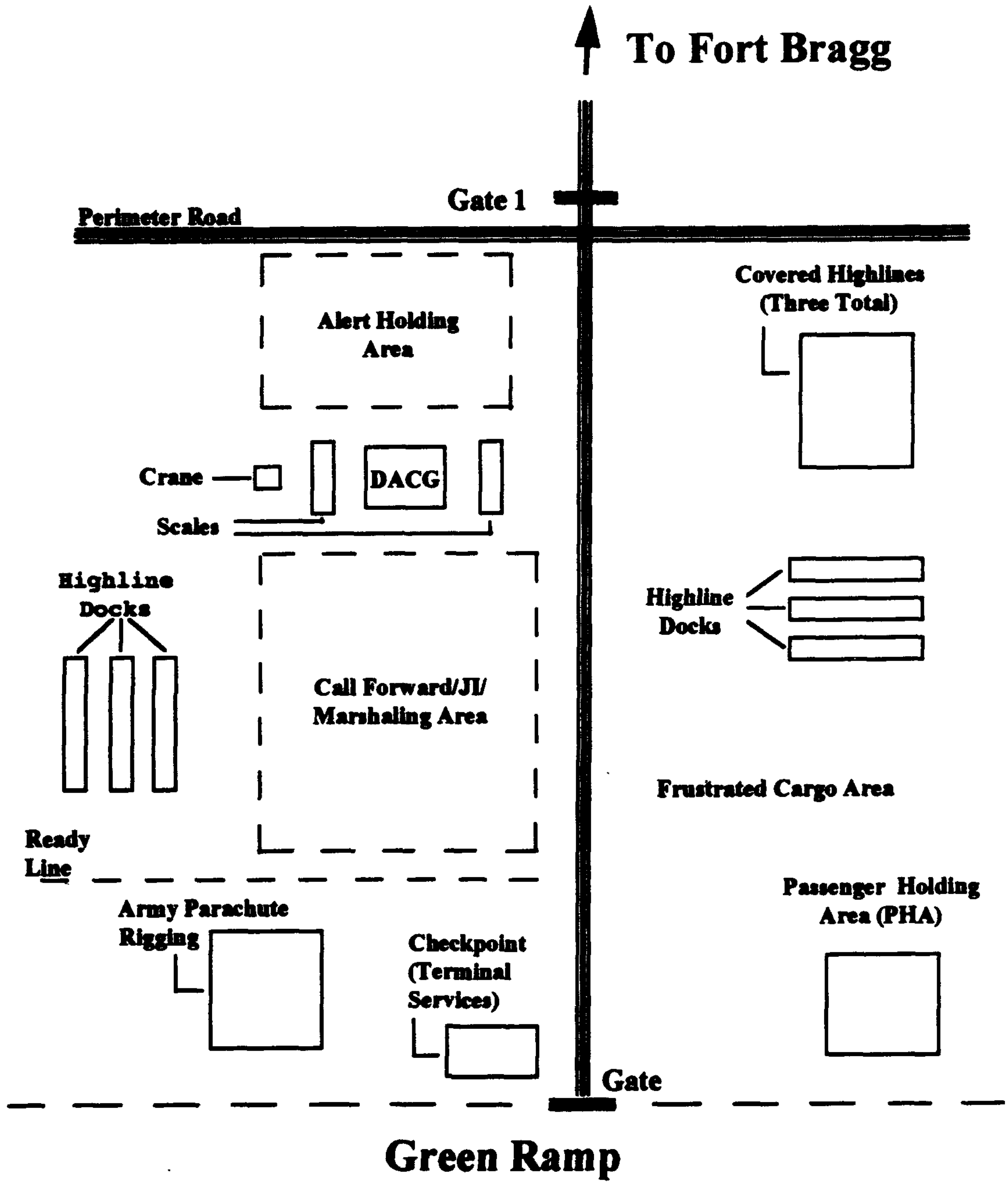

Figure 5. Layout of the DACG Operation

on K-loaders is not desirable since these pieces of equipment are needed to load aircraft. Airland cargo is

weighed at either scale and is then staged in the Call Forward Area (Rogers, 20 March 1993). The DACG Alert Holding Area can hold approximately 15 C-141 equivalent loads (about 165 463L pallets) at a time while the Call Forward Area can hold roughly 26 C-141 equivalent loads (or 310 463L pallets) (Joint, 1990:85-87). The six uncovered highline docks in the DACG area can store 40 eight-foot platforms, which is approximately four C-141 loads. Additionally, there are three covered highline docks available that hold another 20 eight-foot platforms, or roughly two C-141 loads (Joint, 1990:87; Phillips, 19 March 1993). Covered highlines are preferred to uncovered highlines because an airdrop platform stored on an uncovered highline will get wet if it rains. The extraction chutes, which are small parachutes rigged to extract the platform from the aircraft during flight, must remain dry in order to function properly. There are also 30 rollerized flatbed trailers available for use should they be needed (Williams, 16 December 1992). The Passenger Holding Area located at the bottom right corner of Figure 5 accommodates approximately 400 passengers for short periods of time. This number varies up or down by about 50-75 passengers depending on whether they are paratroopers or regular passengers. Paratroopers require more space for their equipment and thus fewer can be processed through the PHA at one time (Joint, 1990:88). Green Ramp provides a total of

14 C-141 and 4 C-5 parking spaces. Alternatively, if only C-141s are on the ramp, then there is room for 22 C-141s at any one time . There are also three parking spots for either C-141s or C-5s that are used by both deployment operations (Comstock, 1 June 1992).

Personnel. Although adequate numbers of personnel with the appropriate specialty skills are an important requirement in any operation, people can be moved temporarily from other bases to fill shortfalls relatively easily. As a result, only personnel with a few critical skills were considered in the modeling effort. Briefly then, these skills are qualified joint airdrop inspectors, qualified joint inspectors ; MHE operators who are qualified on 25K-, 40K-, TAC-loaders, and 10K forklifts; and load team chiefs (Phillips, 19 March 1993).

Material Handling Equipment. The availability of an adequate amount of Material Handling Equipment (MHE) is a critical requirement in any deployment operation. Without it, a deployment will not happen. Adding to the MHE availability problem is the fact that the most critical types of MHE, 25K-, 40K-, and TAC Loaders, are extremely maintenance-intensive. The amount of each type of MHE authorized and actually assigned to Pope AFB as of 22 October 1992 is listed in Table 2 (Support, 1992). According to air transportation personnel assigned to 3 APS, this amount of MHE is typical, although some of the TAC-

TABLE 2

463L MATERIAL HANDLING EQUIPMENT (MHE) STATUS
AT THE 3RD AERIAL PORT SQUADRON (Support, 1992)

Type	Authorized	Assigned
40K Loader	8	6
25K Loader	15	11
TAC Loader	12	12
Cochran Loader	6	4
10K AT Forklift	21	21
13K AT Forklift	4	4
10K STD Forklift	15	14
Stair Case TRK	4	4
Latrine Svc TRK (LST)	2	3

Loaders and all-terrain (AT) forklifts may be lost due to the squadron's redesignation from a mobile aerial port squadron (MAPS) to an APS (Phillips, 19 March 1993).

Problems Identified/Recommendations Made. In the past there have been several large-scale contingency operations involving the 82nd Airborne, such as Operations JUST CAUSE and DESERT SHIELD, that have shown significant limitations with the deployment infrastructure at Pope AFB. These limitations run the gamut from ramp space to facilities and equipment. This section discusses those problems identified by the Joint Committee that studied the XVIII Airborne Corps DESERT SHIELD deployment.

The Joint Committee identified a number of resources that proved to be inadequate and made a number of

recommendations to overcome these limitations. First, the weighing and inspection of cargo at the DACG was identified as a bottleneck. This is because the DACG only has two scales at its facility. These scales are used to weigh heavy airdrop platforms and vehicles so that the center of balance can be determined. These scales limit the airland configured cargo throughput capacity of the DACG to 60 C-141 equivalent loads a day (Joint, 1990:86). Another area of concern is passenger processing, holding, and loading. Deploying Air Force personnel are processed, held, and loaded from the Mobility Passenger Terminal adjacent to Silver Ramp, while deploying Army personnel use the Passenger Holding Area adjacent to Green Ramp. The two facilities are fully utilized during mobility operations, so consolidation of operations is not feasible (Loveland, 19 June 1993). In fact, the Operation DESERT SHIELD Joint Committee recommended the Passenger Holding Area be expanded beyond its current capacity of 400 personnel. The limitation imposed by the lack of passenger processing space is evident in the fact that a requirement to load two wide-body commercial passenger aircraft within two hours of each other would easily congest the system during a deployment exercise or rapid insertion contingency operation (Joint, 1990:33). The Joint Committee also recommended enlarging the DACG cargo marshaling area to accommodate 30 C-141 equivalent loads and increasing the number of highlines so

that more palletized loads and airdrop platforms can be staged for loading (Joint, 1990:88). One last limitation covered in the Joint Committee Report is the lack of an adequate hazardous and explosive cargo storage area at Pope AFB. There is no permanent storage area near the DACG for hazardous and explosive cargo. During normal operations this type of cargo can only be stored in the marshaling area for up to four hours (Joint, 1990:88).

The various elements and parameters just discussed must be incorporated in the joint deployment computer simulation model. Through experimentation with this model, decision makers may well be able to more accurately determine the asset levels required by future simultaneous deployments from Pope AFB. The remainder of this literature review explores information that was helpful in ensuring the deployment model constructed is, indeed, a useful tool.

Simulation in Logistics

Since World War II first highlighted the value of logistics to successful military planning, more and more mathematical and simulation modeling techniques have been applied to the logistics planning and decision-making process (Hughes, 1984:31). This increased reliance on modeling and simulation by logisticians is attributable in large part to the increasing complexity of modern weapon systems and the fast-paced, fluid nature of the Airland

Battle doctrine (Hughes, 1984:230). Today, the proliferation of PC-based simulation software presents logisticians with even more opportunity to use simulation in problem-solving efforts and, simultaneously, challenges them to do so correctly (Schenk, 1992:32).

Simulation of Transportation and Mobility Functions. Within the logistics discipline, transportation problems in general and deployment problems in particular are well suited for study through simulation. Systems that are too complex to be optimized with mathematical models and are not readily available for direct experimentation are prime candidates for simulation studies (Schriber, 1991:6). Before simulation is determined to be the appropriate tool, a minimum requirement is that the modeling effort must contribute to a better decision than could be made without the model (Hughes, 1984:17).

Decision-makers often turn to simulation or mathematical modeling when

> the decision maker has little previous experience making similar choices, when the alternatives are complex, or when the decision is considered important enough to expend the time and effort required to conduct extensive analysis. (Schenk, 1992:32)

Information requirements that may dictate use of simulation include: estimations of real system performance under other than normal operating conditions; evaluations of alternate system designs or parameters; or identification of effects

due solely to causal variables of interest (Kelton, 1982:8). The Pope AFB deployment information required by Air Mobility Command encompasses all of these aspects.

Existing Mobility/Deployment Models. To determine the course of simulation efforts for this study and to familiarize the researchers with the present state of logistics simulation efforts, a review of existing de.loyment models was required. The absence of a general-purpose model that could be tailored to the requirements of this study determined the need to construct a specialized deployment model. The review of established models and simulation studies contributed to this effort.

Although most models researched are much broader in scope (generalized) than the model required for this study, five of those strategic-level models do provide some insights into which elements within the mobilization and deployment processes are perceived to be most significant by military planners in the operations research community. Additionally, a number of special-purpose models which focus on the detailed elements of individual deployment processing systems were studied and provide insights into those variables considered significant in the more "micro-level" models that have been constructed by practicing logisticians and transportation professionals. Although the deployment systems modeled are quite different than the Pope AFB operation, these models provide specific information that is

useful in terms of model development and experimental design.

Established, Generalized Mobility Models. Three early mobility models, the Strategic Mobility Scheduling Model (SMOBSMOD), the Simulation and Gaming Methods for Analysis of Logistics (SIGMALOG) System, and the Force Interactive Response Evaluator of Assembly, Replenishment, and Mobility (FIREARM) model, focus on the ability of the aggregate logistics channel to move materiel and personnel into a specified area in a timely manner (Battilega, 1978:442-463). These models show that the focus of early efforts was on determining capabilities of the existing, aggregate transport pipeline and not on determining the resource levels required at individual hubs to make that aggregate system work at various throughput levels.

The Airlift Flow System (AFS) simulates the strategic airlift system to multiple theaters world-wide. This model uses input data on aircraft, airfields, cargo, and resources to measure the impact of constrained resources upon the airlift system (Catalog, 1988:D-2).

The Aircraft Loading Model (ALM) analyzes loadability, or the ease of loading, of military vehicles on aircraft and provides input to future airlift aircraft and military vehicle designs. This model determines the amount of airlift required to outload (process and deploy) a military force of any size (Catalog, 1988:D-4).

__Relevant Special-Purpose Models__. A large number of simulation studies which used specialized mobility models were reviewed for this research effort; however, only a few were actually relevant. The few studies that were selected provide a good frame of reference for this current study and are discussed briefly below. Each provides insights into either deployment system factors, model design and construction, data collection, validation and verification, experimental design, or a combination of these areas.

In one of the studies reviewed, Captain James Liggett developed a model to help facilitate efficient allocation of resources and determine extended deployment processing capabilities of a unit located at Kelly AFB TX (Liggett, 1989:5). Model development and experimentation appear to be basically sound; however, one shortfall is the apparent lack of participation by the client during model design and validation. Thomas Schriber maintains that

> The probability that a simulation project (or any technical project, for that matter) will be successful will be increased significantly if time and attention are invested in the project by the client. (Schriber, 1991:11)

Liggett's thesis study uses the model to conduct two experiments. The first experiment attempts to determine the timing of the first late aircraft in a given deployment flow. The second experiment was designed to determine a realistic deployment schedule--one that could be met using

available resources--by estimating the average number of late departures during a 5-day period (Liggett, 1989:26-27).

In another simulation study of interest, Captains Michael Reusche and Vaughn Wasem developed a model to determine the manning requirement of deployable Mobile Aerial Port teams given workload data and estimated processing times for a specified deployed aerial port operation (Reusche, 1982:6-9). A number of simplifying assumptions are made in this modeling effort, ranging from motivated personnel to constant interarrival times for cargo delivery (Reusche, 1982:9-11). At first glance, many of these assumptions seemed to be a leap of faith; however, as the current study progressed, the researchers determined them to be acceptable approximations of reality and in many cases necessary to the modeling effort.

In yet another AFIT thesis reviewed, Major Thomas Christensen and Captain Gerald White used an existing model of an Aerial Port of Embarkation (APOE) base reception operation that was originally developed by First Lieutenant Larry Fortner. Their research built on the previous modeling effort through further validation of the model and substantiation of the previous assumptions (Christensen, 1983:9). They then used the model to conduct experiments designed to estimate the reception base's cargo and passenger staging capacities and to identify potential bottlenecks (Christensen, 1983:59).

The final simulation study presented here was acquired too late in the current study to be highly useful to the modeling effort of this research; however, it contains a wealth of information that cannot be omitted. The value of the results of the simulation study are, themselves, questionable since they were arrived at through one replication, using unlimited capacities for the personnel and MHE resources. However, the value of the study is its discussion of the algorithms and simulation models that have been developed over the years to gauge the capabilities of air freight resources. The thesis, written by Captain Michael Fredette, offers the most comprehensive coverage of the topic found. Of particular interest are a series of models developed during the late 1970s that used simulation to model the Dover AFB aerial port freight operation. The first two models in this series were developed by Pritzker and Associates on contract to HQ MAC (since redesignated AMC) and provided resource requirements and maximum aerial port throughput. The third and final effort in the series culminated in the Air Cargo Reception and Distribution Model (ACRDM), which uses over 90 variables and parameters to calculate aerial port throughput and resource utilization (Fredette, 1986:18-28). Fredette's coverage of those models should be used as a starting point for any future attempts at modeling aerial port operations.

General Simulation Techniques

The literature reveals a vast array of techniques that can be used in model construction, validation, verification, and experimental design. In any particular application, the tools used will be driven by the purpose of the simulation study, the degree of confidence required in the simulation results, and the time and money available for the research effort (Sargent, 1991:37).

Model Construction. The modeling of an actual system is considered as much an art as a science (Banks and Carson, 1984:13). Osman Balci asserts that

> Given a set of objectives, if ten economists are asked to build a simulation model of the U.S. economy, each one will come up with a model which will produce a different set of results. The differences in the results are considered normal and as expected under the paradigm of the art of modeling. (Balci, 1989:64)

He goes on to explain that the art of modeling is a balancing of opposites; the inclusion of essential system elements without unnecessary detail. The result when this art is properly applied is an abstraction of reality that is constructed for a specific purpose, the representativeness of which should be judged only with respect to that purpose (Balci, 1989:64).

Although no rigid rules or algorithms prescribe *the* method for constructing accurate simulation models, Balci provides an excellent framework from which to approach the problem. Model formulation can be described as the process

of first forming a conceptual model of the system and then sequentially transforming this concept into a communicative model, a programmed model, and then finally an experimental model. Validation is performed not as a discrete step, but continually, throughout the process. Balci's proposed life cycle of a simulation study is graphically portrayed in Figure 6 (Balci, 1989:62, 64-65).

Development of the conceptual model is the first step in the construction process. A conceptual model is the system as it exists in the mind of the modeler. During this phase, the modeler should not be encumbered by a specific simulation language as this can result in a much more complex, and thus error-prone model (Balci, 1989:62,64).

As the model is transformed into a communicative form, it is important the modeler begin with a simple model and then gradually add in the minimum complexity needed to represent the system (Banks and Carson, 1984:13). Offering a means of fitting the system representation detail to the purpose of study, Randall Sadowski states that

> One technique that helps determine what needs to be included is to decompose the perceived model into smaller components; e.g., buffers, operator logic, job priorities, job release strategies, etc. Then examine each component and ask the following question: if this component is not included, will it have a significant effect on the key performance measures. (Sadowski, 1989:73)

One popular method for constructing the communicative model is through the use of a flow chart (Bobillier, 1976:36). A

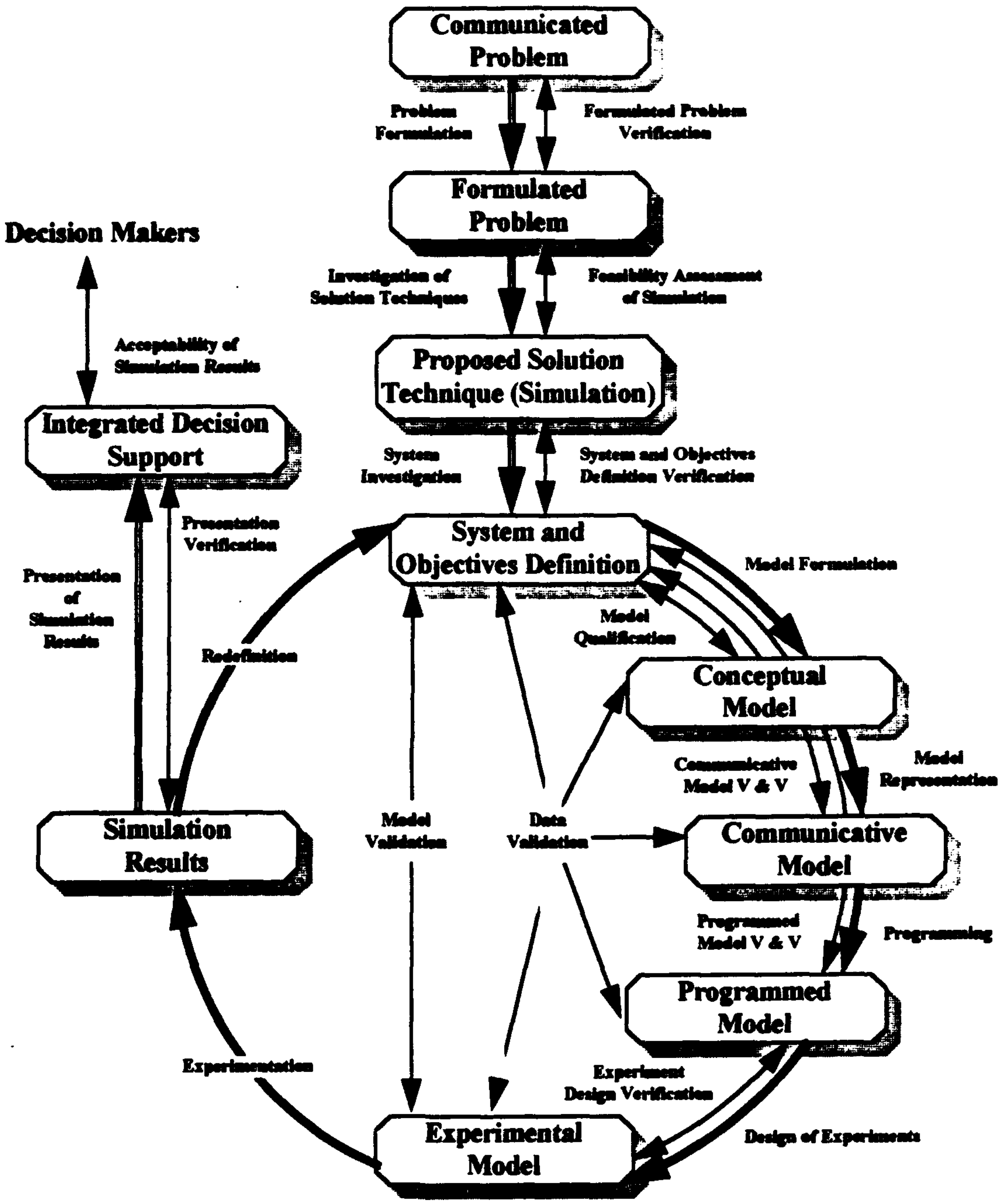

Figure 6. The Life Cycle of a Simulation Study (Balci, 1989:63)

number of other methods are also available, including pseudo code, activity-cycle diagrams, and specification of conditions (Balci, 1989:65).

Since most real-world systems exhibit random behavior, a method is needed for including this randomness when the conceptual and communicative models are transformed into the code of a programmed model. This is accomplished by either gathering data on those variable system elements and then using that data, or distributions derived from that data, as input to the model, or from one of a number of heuristic methods available. The result is either a self-driven or a trace-driven model. In a self-driven model, input values are sampled from a specified probability distribution through the use of random numbers. In contrast, a trace-driven model uses sequential data inputs directly from empirical measurement of the actual system (Balci, 1989:64).

Once the communicative model is coded into a computer simulation language and a programmed model is obtained, further coding to set up the model for a designed experiment produces an experimental model.

Verification/Validation. To ensure a simulation model provides information that is useful to decision-makers, it must do two things. First, it must be an accurate reflection of the actual system being modeled. While it doesn't have to be an exact duplication of the system, it must contain those system elements that make up the essence of the

system. This is known as validation. The model must also be constructed accurately. The logic contained in the coded model must work as intended by the conceptual model. Ensuring this proper execution of the program logic is known as verification (Schriber, 1991:11-13).

A number of methods may be used in verifying and validating models throughout development. According to Robert Sargent, models may be validated by any of the following methods:

1) Use of animation to observe model execution;

2) comparison to previously validated models;

3) degeneracy tests;

4) comparing simulated events to behavior of the actual system modeled;

5) extreme-condition tests;

6) using judgment of system experts (face validity);

7) checking model results against hand calculations;

8) comparing simulation results with historical data;

9) sensitivity analysis; and

10) Turing tests (another use of system experts) (Sargent, 1991:39-40).

It is extremely important to note that Balci, among others, stresses that verification and validation should be accomplished during each phase of model construction, not just after the model has been coded. Any time code is added to or deleted from the program model, as when configuring

the model for different experiments, validation and verification should be re-accomplished (Balci, 1989:62).

Summary

This chapter reviewed information relevant to the development of a computer simulation model of the joint deployment system at Pope AFB. First it explained general Air Force, airlift, and deployment doctrine, which explained the concept of composite wings and joint forced entry operations. Next, the review explained the deployment environment of Pope AFB and highlighted some of the limitations inherent in that environment. Current models of mobility operations were discussed next. The review concluded with a brief look at some general modeling techniques that provide a framework for this study's modeling effort.

III. Model Development

Introduction

This study uses the General Purpose Simulation System/H (GPSS/H) simulation language as the medium for modeling the Pope AFB deployment system. The objective of the research is to first determine the feasibility of a joint Army/Air Force deployment from Pope AFB with the system currently in place and then look at the sensitivities of various parameters. To achieve this objective, the study includes three broad segments of work: model development, experimentation, and analysis. Due to inadequate input data and time constraints, only the airdrop portion of the model was finished and no true experimentation or analysis was accomplished.

Modeling Objectives and Boundaries

The first steps in developing a computer simulation model are determining what you want it to do and what the process boundaries are. Model development began with determination of the specific information desired by the Transportation Plans and Programs department at Air Mobility Command, Scott AFB, IL, detailed definition of the Pope AFB deployment system, and identification of those variables and parameters that must be incorporated in the model and those that may be excluded. Model boundaries are clearly defined and any assumptions are identified. These boundaries begin

when a passenger or piece of cargo is delivered to the aerial port and end when the aircraft blocks out (taxis away from) of its parking spot. Model development proceeds by transforming this beginning, conceptual model of the deployment system into the code of a computerized simulation model. The conceptual model was validated and the computer model was verified and partially validated. More will be said on validation and verification in Chapter 4.

Assumptions

A number of assumptions were made in developing a model of the Pope AFB deployment operation; however, only those pertinent to the performance of the model are discussed. The major assumptions that went into model construction include the following: 1) aircraft arrive as scheduled in the Airlift Flow Plan for the exercise, 2) airdrop cargo arrives approximately as scheduled, with airland cargo arriving with slightly more variability, 3) use of 25K-loaders is preferred in the DACG airdrop operation, while use of 40K-loaders is favored in the 23rd Wing mobility machine and the DACG airland operation, 4) all airdrop cargo is shuttled from the scales directly to the highlines, 5) all cargo and passenger processing times, excluding the time required to correct frustrated cargo, follow a triangular distribution, 6) frustration times are uniformly distributed, 7) unlike the airland cargo, airdrop platforms

are not frustrated, 8) TAC Loaders, which are basically K-Loaders designed for tactical use on unimproved surfaces, are not differentiated from 25K-Loaders, and 9) all highlines and rollerized flatbeds are lumped together in a common pool of storage space. These assumptions were discussed with experts who routinely work within the Ft Bragg/Pope AFB DACG and wing mobility operations and were determined to be valid (Rogers, 20 March 1993).

Assumption 1. The first assumption, that airlift arrives as scheduled, is a very likely occurrence for the Pope AFB operation in this scenario. Even during past major contingencies or wartime situations when the airlift system was strained to maximum capacity, the highest airlift priority was given to the rapid insertion forces of the 82nd Airborne Corps. Thus for the joint deployment scenario of the exercise, it is highly likely that the required airlift will be available. That this airlift will arrive on time is not so certain since aircraft are subject to maintenance, weather, or a host of other problems. Variability in aircraft arrival could be added to the model at a later date; however, the researchers do not feel this is an intrinsic part of the cargo and passenger processing system. If for some reason no aircraft arrive, cargo and passengers in the actual system would continue to process until all storage space is utilized; at that time the system will stop. In a dense flow of similar aircraft, such as the one

planned for Pope, one late aircraft will merely cause the chalk planned for that aircraft to be loaded on the next arriving aircraft.

Assumption 2. That airdrop cargo arrives at the scales in approximate chalk (aircraft load) order and close to the scheduled scale time probably seems to be a weak assumption to anyone who has participated in a mobility exercise, but due to the unique nature of deployment operations at Pope AFB it is a reasonable assumption. Increments on airdrop platforms cannot be stored on the ground because they cannot be picked up and transported with a 10K forklift as can regular 463L pallets. This in effect forces the platforms to be stored on either K-Loaders, highlines, or rollerized flatbed trailers. Since all three types of equipment are in short supply at Pope AFB, and the K-Loaders are needed to load aircraft, it is imperative that airdrop cargo be delivered by units at or near the scheduled times. If it does not, the storage space could be taken up by cargo that is not departing until much later. If this were allowed to happen with any regularity it would tie up the scales and platform storage equipment, thus making it impossible to weigh and set up higher priority cargo arriving after the out-of-sequence cargo.

Airland cargo will tend to arrive more randomly than airdrop cargo with some increments arriving potentially very late. The main reason for this is that the buildup and

delivery of airland cargo is not as strictly controlled as it is for airdrop cargo. This randomness is modeled by having slightly more variability in the arrival times for airland cargo. Airland cargo, both rolling stock and palletized, can be stored on the ground in the marshaling yards so it won't tie up constrained MHE while in storage. In those instances where cargo shows up very late, it is usually bumped off the chalk and replaced with other cargo so it won't delay aircraft departure. It would be extremely difficult to simulate increments being swapped from one chalk to another and very little authenticity would be gained relative to the amount of additional model detail required. For the most part, cargo will arrive approximately in chalk order. Whether or not the cargo within that chalk is in the same order as load planned has little or no effect on model or actual system performance. Replacing very late increments will cause disturbances in load planning and paperwork, but for the most part would not affect on-time aircraft departures.

Assumption 3. The assumption dealing with K-Loader usage is driven by the limitations in the GPSS/H language against looking backward or forward in time. GPSS/H can only act on what is occurring in the model at the present time; it cannot be made to think like a person in planning for future events. In order to exactly model the decision-making process of determining whether to use a 10K forklift,

a 25K-Loader, or a 40K-Loader for a given chalk, the program needs to be able to "see" not just the increment of cargo currently being processed, but all of the increments that follow for at least the next four or five chalks. Since the model could not see into the future, a DACG bias for 25K-Loaders and an Air Force mobility machine bias for 40K-Loaders was purposely built into the model. For routine operations in the scenario under study, this bias does generally mirror the actual decision-making process. Since much of the cargo moving through the DACG operation will be too heavy for a 25K-Loader, personnel in charge will tend to use 25K-Loaders for any cargo increments that will fit on one and save the 40K-Loaders for those increments that won't fit on a 25K-Loader. Meanwhile, in the 23rd Wing mobility operation, most of the cargo will be standard sized rolling stock or 463L pallets which will easily fit on either a 25K- or 40K-Loader. In this situation, the decision-maker would choose to use a 40K-Loader first, as long as other increments on the chalk would fill up the rest of the loader. This would reduce the number of pieces of MHE necessary to load the aircraft. These built in biases are an acceptable tradeoff. While the K-Loader loading segments of the model will not accurately represent all MHE decisions, they will accurately represent the more routine ones.

Assumption 4. To simplify model construction the assumption is made that all airdrop platforms will be shuttled directly from the scales to the highlines since that is what happens most of the time during a large scale deployment. After the first few chalks have been through the scales the MHE gets tied up with cargo, so in order to keep the scales busy the airdrop platforms are stored on highlines or rollerized flatbeds. Since airdrop platforms must be stored on highlines, rollerized flatbeds, or K-Loaders, and K-Loaders are needed to load the aircraft, the platforms are stored on the highlines or flatbeds until load time. The scale/crane combination is a capacity constrained resource and as such should be kept busy at all times. By moving the platforms directly to the highlines or flatbeds instead of waiting for K-Loaders, the scale is kept busy, at least until all highline and flatbed space is taken and all K-Loaders are in use. For modeling purposes, rollerized flatbed storage space is grouped with highline space since both provide the same service: storage for airdrop platforms.

Assumption 5. Due to problems experienced during the data collection process, the amount of data required to develop the actual distributions of many stochastic model elements was not obtained. In fact the volume of data required for this effort could be a research study in itself. As an acceptable, and intuitively appealing

approximation, all of the cargo and passenger processing times, with the exception of correcting frustrated cargo, are drawn from triangular distributions that were fit from the available data, as well as interviews with system experts. At least for the DACG operation, which is the operation of most concern among planners, these distributions should be very near reality. Air Transportation personnel, not augmentees, man the weighing, Joint Inspection (JI), MHE operation, and aircraft load team supervision positions within air terminal services section. As a result of this expertise, for a given type of equipment the required processing time will vary only slightly, with no extreme measurements; hence a triangular distribution. In a triangular distribution the modeler determines the minimum, maximum, and mode times from the raw data and then enters them into the model using the built in GPSS/H RVTRI function. The model draws numbers from a random number generator and uses these numbers to assign processing times. While the assumption of triangular distributed processing times may not be as precise an approach in the Air Force mobility segment, it is felt that degradation of model accuracy will be minimal.

Assumption 6. Cargo frustration times (the time needed to correct discrepancies found during joint inspections) are modeled as uniformly distributed because frustrated

increments exhibit a very wide range of possible correction times, each with an equal probability of occurrence.

Assumption 7. It is assumed that airdrop loads aren't frustrated. Although most transportation personnel, due to their familiarity with Air Force mobility, may find this assumption odd at first glance, it is a very accurate assumption. This is due to the importance placed on properly rigging airdrop loads. Any time a 30,000 pound piece of cargo is extracted from an airborne aircraft the potential for disaster exists. Airdrop operations even with properly rigged loads are dangerous; with improperly rigged loads, they can be deadly. Because of this, these loads receive special attention from the initial build-up of the increment to final loading and the subsequent Joint Airdrop Inspection (JAI). Deficiencies receive a high priority and are corrected quickly without "officially" frustrating the increment. The airdrop segment of the model contains a mechanism which would allow the modeler to frustrate the increments by changing the frustration probability in the input data processing times matrix from zero to some other number.

Assumption 8. The assumption that TAC Loaders are considered the same as 25K-Loaders is probably the most limiting assumption made. While TAC Loaders have more capabilities than 25K-Loaders (a TAC Loader with an extender can carry 4 pallets and 30,000 pounds, while a 25K-Loader

can carry only 3 pallets and 25,000 pounds), the additional detail needed to include them in the K-Loader selection logic and the extra debugging needed are prohibitive due to the time constraints in model construction. The assumption seems more reasonable when you consider that the superior loading capabilities of the TAC Loader are somewhat offset by its lower Vehicle in Commission (VIC) rate and higher shop time per vehicle (84.0% VIC for TAC Loader vs. 97.8% VIC for 25K-Loader and 8.4 days shop time for TAC Loader vs. 3.8 days shop time for 25K-Loader) (Grafton, 21 April 1993).

Assumption 9. Pope AFB has 3 covered and 6 uncovered highline docks along with access to several rollerized flatbed trailers, all of which are used to store airdrop pallets. While each of these docks and trailers are separate entities, modeling them as such would be extremely difficult and not add to model validity. While chalk integrity is maintained in the real system, the concern here is on total platform storage capacity, not the order in which increments are stored.

Data. The model requires a large amount of input data, both for the stochastic processes of the model as well as for the individual units of traffic that move through the model during simulation of a specific scenario. As previously mentioned, problems in data collection resulted in some required tradeoffs in model accuracy. These tradeoffs relate only to the model elements that draw random

numbers from a distribution predicated on that input data. The output data of interest are the number of late aircraft departures and the mean tardiness. Actual model output consists of actual terminal complete times, which are the times at which aerial port personnel complete loading of all passengers and cargo, and the scheduled terminal complete times. The parameters in the model were systematically changed during verification efforts to determine the effect of these changes on the time the chalk was terminal complete. The scheduled terminal complete time is 30 minutes prior to scheduled departure time.

The input data are contained in three trace files which drive the deployment simulation model. The information from these trace files is either assigned to the "Xacts", which are transactions representing aircraft or increments, or read into a data matrix for use in the model. The first trace file in this model is called LDINFO.TXT (Appendix E) and it contains chalk number, mission number, number of increments, scheduled departure time, branch of service, and aircraft type for each aircraft load. This information is assigned to the lead Xact which represents the aircraft itself. This file was built using information contained in the Airlift Flow Plan and aircraft load plans for the joint deployment exercise. The model uses this information to schedule increment creation and to determine how many increments to create for each chalk. Each line in this file

is for a separate chalk with the first column being the chalk number and the second column the mission number. The modeler needs to assign a chalk number to each of the missions in order of their departure time. The third column contains the number of increments on the chalk. This number is derived from load plans for each chalk. If there are passengers on the chalk they are modeled as one increment regardless of the number. The number of increments column is used to determine how many increments to create when the lead Xact is split. The fourth column is the departure time of the chalk. It is one of the most important pieces of information that each increment will carry with it, since everything in the process revolves around aircraft departure time. The fifth column contains a code for the branch of service for the chalk. Air Force loads are coded as a 100 while Army loads are coded as a 300. These codes are used to direct each increment to the correct model segments for processing. The sixth column specifies the type of aircraft each chalk is to be loaded on. A 005 in this column specifies the chalk is to be loaded on a C-5, while a 141 designates the chalk as going on a C-141. All the information needed for this file, with the exception of the number of increments, was found in the Airlift Flow Plan for the joint exercise.

The model gets increment specific information through the input trace file called LDPLANS.TXT (Appendix F). The

increment Xacts are created after the lead Xact goes through the split block. These increment Xacts pull information sequentially from this file, so it is important the files are arranged in the correct order. Each line in this file contains the increment number and type of load for that increment. The airdrop portion of this file was created using load plan information provided by the 82nd Airborne Division. At the time of model construction neither the Army nor Air Force had developed load plans for their airland portions of the exercise. The modelers developed Air Force load plans for the joint deployment by fitting current 23rd Wing deployment load plans, which use C-141 aircraft exclusively, to the flow for the exercise. Army airland load plans were constructed by subtracting the amount of cargo deploying via airdrop from the total equipment shown in the Deployment Ready Brigade Equipment Listing and putting it on chalks according to priorities listed by Maj Young, Army Ground Liaison Officer (Young, 19 March 1993). The first column in each line specifies the increment number for each piece of cargo, while the second column indicates what specific type of cargo it is. The third column shows the chalk number for each of the first increments. This data is used only to aid in building and troubleshooting the file and is not read by the computer since it is separated from the second column by more than one space.

The final trace file needed to run the model is the increment data matrix file PROCTYM.TXT (Appendix G). This file contains the following information, in column order, for each of the increment types: increment type code, weight, number of pallet positions taken up by cargo, minimum weigh/JAI/JI time, maximum weigh/JAI/JI time, mode weigh/JAI/JI time, minimum loading time, maximum loading time, mode loading time, cargo type code (pallet=1, rolling stock=2, airdrop platform=3, passengers=4), frustration probability, and increment type description. The last column, containing the increment type description, is used for reference only and is not read by the computer. The increment data matrix for this model contains 108 rows with each row corresponding to an increment type being transported in the joint deployment. Additional increment types could be added to the matrix as long as the statement defining the matrix in the model is changed accordingly. Passengers are not modeled individually in this model, but rather in groups of 100, 75, 50, 25, or 10. They are included in the increment data matrix file but have zero values in the areas that are not applicable, such as weighing and frustration probability. The weight of each increment type is derived from load plans or standard planning data weights. The pallet positions taken up by the cargo are determined by dividing the length, which is also in the load plans or standard planning data, by 88 inches.

If the increment is narrower than a 463L pallet, for example a C-130 towbar, then the modeler divides by 88 inches and makes an allowance for the narrower width. Due to problems in data collection, the values in the increment data matrix file are somewhat suspect. More is said on this in the variables segment.

Parameters. The parameters used in the model, which are elements that do not change during a model run, such as the number of highlines or 40K-Loaders available, are selected using the modelers' past experience with the Pope AFB mobility system and expert opinion from current 3rd Aerial Port Personnel (Rogers, 20 March 1993). The following parameters are used in the model: number of roll on/off scales, amount of highline/rollerized flatbed space, number of 40K-Loaders, 25K-Loaders, and 10K forklifts, pallet positions of storage space in the Army Call Forward Area and Air Force marshaling yard, and the number of joint inspectors, MHE operators, loadmasters, and Aerial Port load teams.

Not every parameter of the real system is included in the model because the excluded parameters would not add appreciably to model performance and validity. Examples of real system parameters that the modelers and system experts feel are insignificant to modeling the cargo and passenger flow during a deployment exercise are: number of load planners, size of the Army load team pool, explosive cargo

storage space and aircraft parking hot spots. Prime movers, vehicles that pull or push trailer type pieces of rolling stock onto an aircraft, are excluded from the Army airland deployment section of the model because most trailers are transported attached to a prime mover. The paperwork for a load is not considered a system constraint so the number of load planners is not an important parameter. The Army load team pool is a group of nondeploying Army personnel used to assist the Air Force load team in pushing airdrop platforms onto the aircraft and in securing loads to the cargo floor. The load team pool was not modeled as a parameter since the Army can always provide an adequate number of team members. Explosive cargo storage space and aircraft "hot spot" parking are not included as parameters because during a contingency the special storage and aircraft parking requirements for explosive cargo can be waived. The extra time that it takes to transport cargo to the hot spot is included in the loading time distributions.

Variables. The model variables are processes that cargo increments go through from entry into the mobility system until loading onto an aircraft. The variables can take on a range of values. Some variables are cargo specific, like the time it takes to load a specific piece of equipment, and some are general, for instance, the time it takes to drive a K-Loader from the scales to the highline docks. The cargo specific variables are assigned to each

increment type through a matrix file. The cargo specific variables of interest used in the model are the weigh/JAI times for each increment type and the time it takes to load each type on the aircraft. As was mentioned earlier, these variables are assumed to follow a triangular distribution, although not enough data were collected to prove a true distribution pattern for any of the increment types.

The model contains many general variables which apply to every increment, regardless of the type. The general variables in the model are as follows: the time to move a piece of MHE or rolling stock from the scales to the highlines or staging area, cargo frustration times, time to push an airdrop platform from a K-Loader to the highline or rollerized flatbed, time to push platform from the highline or rollerized flatbed to a K-Loader, time to drive a piece of MHE or rolling stock from the highlines or staging area to an aircraft, time to position a K-Loader behind an aircraft, and the time for an aircraft to block out of its parking spot. The modelers obtained times for these variables of interest, but not enough to construct valid distributions. For simplicity these general variables are assumed to follow a uniform distribution.

Summary

This chapter first explains modeling objectives and boundaries. Next it discusses assumptions made about the

Pope AFB deployment environment to facilitate model construction. The input data required to drive the model and the ou.put data produced are then described in detail in the following section. Finally the parameters, such as MHE and manpower availability, and variables, such as cargo weighing and loading times, are listed and defined.

IV. Model Validation

Introduction

This chapter discusses model validation and verification efforts and identifies the limitations or shortcomings of the deployment model. Model validation is a continuous process that occurs throughout all stages of model building (Balci, 1989:65-68). The first validation stage is the process of determining if the conceptual model is a suitable representation of the real system, while the final stage is to determine if the computer model behaves like the real system. Model verification is the process of assuring the conceptual model is correctly converted to computer code (Schriber, 1991:13).

Validation

Efforts at model validation occurred throughout model development. During the data collection effort, a preliminary validation was performed to ensure the conceptual model accurately represented the deployment system. This was accomplished through an in-depth comparison of the conceptual model flowcharts and the actual system by experienced air freight/passenger specialists assigned to 3 APS at Pope AFB (Rogers, 16 March 1993). Further validation was to be done by comparing the verified computer model to the real system. To accomplish this the modelers obtained an AF Form 68 from a day when the Pope AFB

outload system was extremely taxed with both airland and airdrop missions. The AF Form 68 is a log kept by the Air Terminal Operations Center which contains data pertaining to missions handled by the aerial port for that day. Data included in the AF Form 68 are: scheduled and actual aircraft arrival and departure times, scheduled and actual cargo and passenger loading times, scheduled and actual cargo inspection times, and load plans. From this data the modelers were to make trace files from the actual exercise and run them through the model to see if the model performed as the actual system had. This validation effort was not completed because the data gathered during time studies was incomplete on most increments and nonexistent on the rest.

Verification

After the airdrop portion of the conceptual model was converted into computerized form, the verification phase began. The modelers encountered many problems in this phase and were forced to step through small segments of the model due to its complexity. By stepping through each of the model segments in the test mode of GPSS/H, the modelers were able to debug logic errors and eventually verify that the logic accurately mirrored the conceptual model. After this step was completed, the modelers moved to the next verification step; determining the sensitivity of the model to changes in input parameters.

The sensitivity analysis was accomplished to determine if the model reacted as the real DACG operation would to changes in potential bottleneck parameters. The modelers conducted several runs of one replication each with varied sets of input parameters. The parameter sets used, as well as the results of these runs are shown in Table 3. Although

TABLE 3

SIMULATION RUNS USED IN VERIFICATION

	40K Ldrs	25K Ldrs	H-line Space (PP)	Scales	Late Departures	Mean (min) Tardiness
Treatment 1 Baseline	8	15	100	1	37	596.7
Treatment 2 Fewer K-Ldrs	6	12	100	1	36	597.7
Treatment 3 Increased K-Ldrs	12	20	100	1	37	597.0
Treatment 4 Increased H-Lines	8	15	200	1	37	596.7
Treatment 5 Increase scales	8	15	100	2	34	229.1
Treatment 6 Increase All	12	20	200	2	30	145.3
Treatment 7 Scales to 3	12	20	200	3	19	68.0

PP = Pallet Positions

one replication isn't adequate for basing policy decisions, it served to roughly test sensitivity.

The first four treatments failed to provide results of any meaningful significance. The first treatment in these sensitivity experiments was run under current conditions at

Pope AFB and was considered the baseline. This treatment resulted in 37 late departures and a mean tardiness of 596.7 minutes. The second treatment was with decreased K-Loader capacity. This treatment yielded 36 late departures and a mean tardiness of 597.7 minutes. The third and fourth treatment, like the first two, resulted in no significant change in the number of late aircraft departures or in mean tardiness. Treatment three increased the number of K-Loaders available over the current Pope AFB conditions, while treatment four kept all the parameters at baseline levels except the amount of highline/rollerized flatbed space, which was increased from 100 pallet positions to 200 pallet positions. This result seems to indicate that K-Loaders and highline docks probably were not the constraining resources at the baseline level.

While the first four treatments produced insignificant results, the last three treatments produced results that were not only significant, but also in line with expected system behavior. Treatment five kept all parameters except the scales, which were increased from 1 to 2, at baseline levels. This treatment produced three less late departures and reduced mean tardiness by 367.6 minutes. This indicated that the scales were a capacity constrained resource, a conclusion already reached by the Joint Deployment Study group and other past studies (Joint, 1990:86). The sixth treatment was run with the scales set at 2 and all other

model parameters at increased levels. This treatment resulted in 4 less late departures than treatment 5 and reduced mean tardiness by 83.8 minutes over the previous treatment. The seventh treatment was the same as treatment six except that the number of scales was raised to 3. This treatment reduced late departures by 11 and decreased mean tardiness by 77.3 minutes in comparison with treatment 6. This indicates the scales were still a capacity constrained resource at this parameter level combination. It is important to realize that these results **do not** indicate what is needed to successfully deploy the airdrop portion of the DRB under the joint deployment exercise. These results only indicate the model is exhibiting the expected behavior to changes in model parameters and leads the researchers to believe the model logic accurately represents the conceptual model. To make any prediction of required resources, this model would have to be completely validated and driven with more accurate input distribution data built using comprehensive time studies.

Limitations

As mentioned previously, due to time constraints several planned segments of the model were not completed and final validation of the completed airdrop portion of the model could not be done due to inadequate time studies. Due to these limitations the modelers concentrated on the area

of most concern to Army and Air Force planners: the airdrop of the Alpha echelon of one DRB. The airland portion of both the Air Force and Army deployment operations has been completed up to the MHE selection point. Another unfinished model segment is passenger processing, although the passenger loading segment is complete. Until these segments are completed the model can only be used for airdrop cargo loads. Since the airdrop loads were all departing on C-141 aircraft only the C-141 aircraft loading segment was completed. The C-5 aircraft loading segment, which would have allowed two K-Loaders to simultaneously load an aircraft, was not started. The modelers obtained MHE reliability information but did not have time to add MHE breakdowns to the deployment model. Since MHE is maintenance intensive, the addition of the breakdown logic is a must to make the model a valid abstraction of the actual system. The fact that this model, as is, should not be used for policy decisions cannot be overstated. The model will not be a useful tool unless and until all of the limitations noted above have been overcome. The next chapter provides the modelers' recommendations for completing for completing the planned simulation study.

V. Recommendations for Future Research

Introduction

This chapter discusses the actions necessary to complete the construction and validation of the deployment model started by this research. First, a comprehensive time study is required to ensure the input data distributions the model uses are accurate. Next, seven more sections of code need to be completed. Finally, the model must be verified and validated. Once these steps are accomplished, the result will be a model that may be used by decision-makers to help determine the manpower and equipment requirements for a major deployment of any unit from any Air Force base.

Comprehensive Time Study

The first, and probably most time consuming effort required is a comprehensive time study of cargo processing times. These times should include: joint inspection times, weighing times, set-up times, and loading times at a minimum. In the case of airdrop loads, pre-joint airdrop inspection/weigh times must also be included. These times should be compiled for each major type of cargo increment. To be useful in determining the appropriate distributions to build, the data must not be averaged; however, slightly aggregating the data into small time buckets would have the effect of providing a useful histogram. The increment types that need to be researched in this time study are listed in

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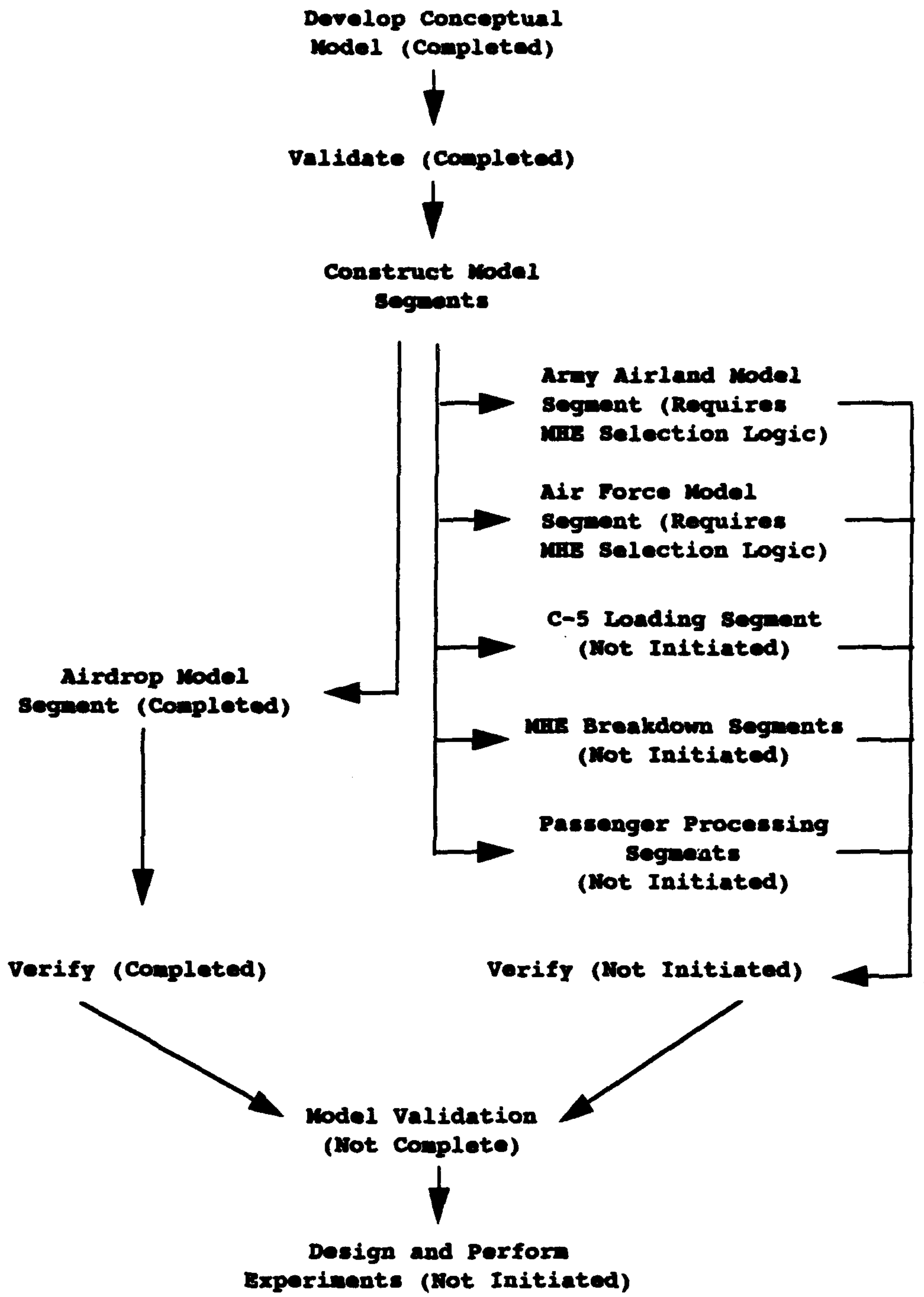


Figure 7. Model Development Status Diagram

Army and Air Force Airland Segments. The increment arrival, weighing, and inspection segments for both the Army and Air Force have been completed, but both need to have MHE selection logic added. Parts of the DACG airdrop MHE selection segment may be used for the airland MHE selection segments, although care must be taken in doing this since there are many differences between the two operations that require different logic. First, the same basic K-Loader selection logic used in the DACG airdrop segment can be used here, but since the Army and Air Force airland operations will be biased in favor of 40K-Loaders instead of 25K-Loaders, the order of K-Loader type attempted first is reversed. This may be accomplished by sending airland increments through the same MHE selection logic but using different Boolean variables for MHE selection. This is but one of the possibilities for finishing the Army and Air Force airland load processing model segments.

Equipment Breakdown Segment. The MHE used in the deployment of forces from Pope AFB is prone to mechanical breakdowns. Since this is an intrinsic part of any deployment process, mechanical failures must be included for the model to be an accurate representation of the real deployment system. This should not be too hard to accomplish. Figure 8 portrays one possible approach. Transactions representing MHE breakdowns are created and

```
         GENERATE    0,,,&KLOADR40
INCOMM40 ADVANCE     RVEXPO((random number stream),_
                     (mean time to failure for 40Ks))
         ENTER       KLOAD40
         ADVANCE     RVTRI((random number stream),_
                     (min repair time), (mode repair time)_
                     ,(max repair time))
         LEAVE       KLOAD40
         TRANSFER    ,INCOMM40
```

Figure 8. Suggested Code for Modeling Equipment Breakdowns

then occupy MHE for an amount of time equivalent to real world repair time. These times should be derived from studies during surge outload conditions.

C-5 Loading Segment. In order for the Army and Air Force airland segments to function properly, a C-5 aircraft loading segment needs to be accomplished. This segment could be patterned after the C-141 aircraft loading logic. The only differences are that two K-Loaders can load at one time with a C-5 and the time it takes to position K-Loaders behind the aircraft is longer.

Passenger Processing Segments. The processing of passengers is not considered as big a system constraint as the scales and highlines, but in order to represent the total deployment environment and make the model of use in generalized deployment scenarios it needs to be included. Two separate segments of code will need to be added since

Army and Air Force passenger processing are independent of each other.

Run Control Segment. This segment will be required before the model can be used for experimentation. To attain the desired confidence level, a number of simulation runs (replications) must be performed for a given parameter set. The run control logic can specify the number of replications necessary to analyze a specific parameter set, automatically switch between parameter sets, or perform a number of other control functions that help turn simulation output into meaningful information.

Complete Model Validation

Once all model segments have been completed and the entire model verified, then final model validation can begin. As was mentioned in Chapter 4, the modelers planned to use an AF Form 68 from a past large deployment to create trace files to run in the model. These trace files would then be run for a predetermined number of replications to achieve the desired accuracy. The results from these runs would be compared to actual departure times from the AF Form 68 to see if the model behaved as the real system. To validate that the model generalizes to other deployment operations throughout the Air Force, these same type runs would have to be accomplished with data from AF Form 68s

from several different Air Force bases under widely varied conditions.

Model Use

At this time it would not be appropriate to use this model for policy decisions; however, upon completion of the actions specified above, this model potentially could provide information on personnel and resource requirements across a broad spectrum of deployment conditions. This would be a definite improvement because the air transportation community has no such tool to assist in decision making at the current time in spite of numerous previous attempts (Coker, 15 January 1993). This model could potentially size the air transportation resources required to support any future contingency operation. The payoffs to further research would be well worth the effort.

To use this model, planners would need a basic understanding of GPSS/H, statistics (confidence intervals in particular), and a full-up version of the GPSS/H simulation language. In order to run the full-up version of GPSS/H, at a minimum a 386DX PC with 4 Mb of RAM is required. Prior to attempting to run this model several trace files must be constructed. See Chapter 3 for instructions. Once GPSS/H is loaded on an appropriate platform and the trace files have been constructed, the program is started by typing "GPSS/H (filename.GPS)" at the "C>" prompt. At the present

time the model filename is "DEPFIN.GPS"; however, this model name may be changed in future modeling efforts. After initiating the program, the user will be prompted to enter values for MHE, storage space, and critical personnel. Once these values have been entered the computer will return to the "C>" prompt. At this time model execution is complete. Refer to GPSS/H users manual for details on output options.

Summary

While this research has been hindered by data collection problems and modeling difficulties, it has been successful in setting the stage for establishment of a generalized mobility model capable of sizing the air transportation support requirements at a single base. The model segment completed displays the expected sensitivities and shows promise that this research has identified a fruitful area for further research. A major difference between this model and many past efforts is that it is driven by data from the actual deployment being planned. Because of this, the model may well provide more accurate information than that normally attained from a generalized model. In effect, it will be possible to customize the finished model to fit any deployment scenario.

Appendix A: Glossary of Technical Terms

AIRDROP PLATFORM - Aluminum platforms of varying lengths for different cargo types, designed to lock into the 463L rail system of military transport aircraft. The cargo is secured to the platform and usually has some type of shock absorbent material between it and the platform.

AIRLAND CARGO - Any cargo which will be unloaded while the aircraft is on the ground. Can be rolling stock, palletized, or floor loaded cargo.

AIRLAND OPERATIONS WING (ALOW) - A new concept in which a composite Air Force wing is designed specifically to deploy with and support Army ground forces.

AIRLIFT FLOW PLAN - Detailed schedule of planned exercise that lists the mission number, aircraft type, configuration, aircraft operator, arrival date and time, destination, departure date and time, reason for stop, user of aircraft, amount of passengers off/on, bulk cargo off/on, oversize cargo off/on, outsize cargo off/on, aircraft ground time, and flying time.

ALERT HOLDING AREA - An area used to stage cargo prior to the joint inspection. Used with an A/DACG operation.

CALL FORWARD AREA - An area used to stage cargo after the joint inspection and prior to aircraft loading. This area is also used with an A/DACG operation.

CHALK - Aircraft load designator. While the term line refers to a specific aircraft, the term chalk refers to a specific load of cargo. Aircraft chalks are then assigned to a line, resulting in an airlift mission, but can be swapped between lines.

CHECKPOINT - The name for the terminal services function at Pope AFB. Checkpoint performs all cargo inspection and loading functions and is in charge of loading Army passengers.

COMPOSITE WING - An Air Force wing in which dissimilar aircraft are combined into one wing.

DEPARTURE AIRFIELD CONTROL GROUP (DACG) - Organization which is responsible for coordinating unit moves and solving any problems encountered with deploying unit's cargo or passengers during a contingency or exercise. It is the liaison between the Air Force and the deploying unit. The branch of the service that composes the majority of the

deploying forces is responsible for providing the DACG. At Pope AFB the DACG is composed of Army personnel.

DEPLOYMENT READY BRIGADE (DRB) - An Army brigade that is ready to deploy immediately upon the outbreak of hostilities. They are "locked and loaded" so to speak.

DUNNAGE - Piece of wood, usually 4"x4", used to support a pallet when stored on the ground. Three pieces of dunnage are required per pallet. Dunnage protects the thin aluminum pallet skin from damage and allows forklifts easy access.

EXTRACTION CHUTE - Small parachute attached to airdrop loads which extracts load from aircraft. Once the airdrop platform has cleared the aircraft the main chutes open and control the platform's descent.

FRUSTRATED CARGO - Cargo which has a discrepancy, discovered during joint inspection, preventing it from being transported on Air Force aircraft. Cargo is considered frustrated until owning unit corrects discrepancy.

GPSS/H - A discrete event, general purpose computer simulation language that is useful for modeling systems composed of units of traffic that compete with each other for scarce resources.

HIGHLINE DOCKS - A rollerized dock which will hold 10 pallet positions of airdrop platforms or 463L pallets. Built at K-Loader height to ease loading/unloading operations.

INCREMENT - Each piece of cargo for a chalk is a separate entity or increment. Passenger loads are considered an increment in the computer simulation deployment model for this research.

INTEGRATED OPERATIONS CONCEPT FOR CORPS ELEMENT AND AIRLAND OPERATIONS WING (CCW) - A concept of operations that is still under development, which pairs an ALOW with an Army Corps element in forced entry operations.

JOINT AIRDROP INSPECTION (JAI) - Inspection accomplished to ensure airdrop platform is ready for airlift and properly rigged for airdrop operations. The inspection is performed by an Air Force loadmaster and a deploying unit representative.

JOINT INSPECTION (JI) - Inspection accomplished to ensure airland cargo is ready for airlift. The inspection is performed by a JI qualified Air Force member and a deploying unit representative.

K-LOADER - Type of MHE used to transport and load multiple pallets onto aircraft or highlines. An integral part of the 463L system.

LOAD PLAN - Document, usually computer generated, which shows the position in aircraft, weight, and dimensions of every increment on a chalk. Also shows passenger load information.

LOAD SET-UP - Activity of positioning increments on K-Loaders in the order in which they will be loaded on the aircraft.

OUTLOAD - Process by which a deploying unit's cargo and personnel are checked to ensure they are deployment ready and uploaded on departing aircraft or other mode of transportation.

PALLET, 463L - Standard Air Force pallet for building up and transporting cargo. Made with an aluminum skin laminated over balsa wood. Designed to lock into the rail system of military transport aircraft. These pallets, along with the side and top nets, straps, and chains and devices used to secure cargo to the pallet, are an integral part of the 463L system which consists of the roller systems on aircraft, rollerized docks, forklifts, and K-loaders.

PARAMETERS - System attribute that does not vary during a certain period of time. In this research, a parameter is an attribute that remains constant throughout one simulation run, such as the amount of MHE available.

PRIME MOVERS - Vehicle used to transport and to load/unload non-powered rolling stock.

RANDOM NUMBER GENERATOR - An algorithm that generates a pseudo-random stream of numbers. For all practical purposes, this stream is a list of random numbers.

READY LINE - The point at which control of cargo passes from the deploying unit to the airlift managing agency. At a base with an organic airlift command and control function, this will be the assigned aerial port squadron, otherwise it will be an airlift control element.

ROLLERIZED FLATBED - A flatbed equipped with rollers that can accommodate 463L pallets or airdrop platforms.

ROLLING STOCK - Any wheeled equipment that is not secured to a 463L pallet.

STATION ACTIVITY REPORT - Scaled down version of the airlift flow plan. Does not contain complete mission itinerary or user information.

STOCHASTIC PROCESS - Any process that contains some degree of randomness.

TACTICAL LOADER - Type of K-Loader that operates on unimproved surfaces.

TERMINAL COMPLETE - Time when aerial port personnel have completed all cargo and passenger loading operations.

TRACE FILE - An input file from which data is drawn as needed by a computer simulation model.

TRIANGULAR DISTRIBUTION - A distribution with a probability density function in the shape of a triangle. The function is defined by the minimum, mode, and maximum values for the distribution.

UNIFORM DISTRIBUTION - A distribution in which all values have an equal probability of occurrence. Defined in GPSS/H by the average and the half-width of the range.

VALIDATION - Determination that a model is an accurate representation of the actual system being modeled. The right things are being measured.

VARIABLE - System attribute which varies over a specific period of time. In this research, a variable is an attribute that changes during one simulation run, such as loading times.

VERIFICATION - Determination that the computer model has been coded correctly. The measurement tool is working properly and taking accurate measurements.

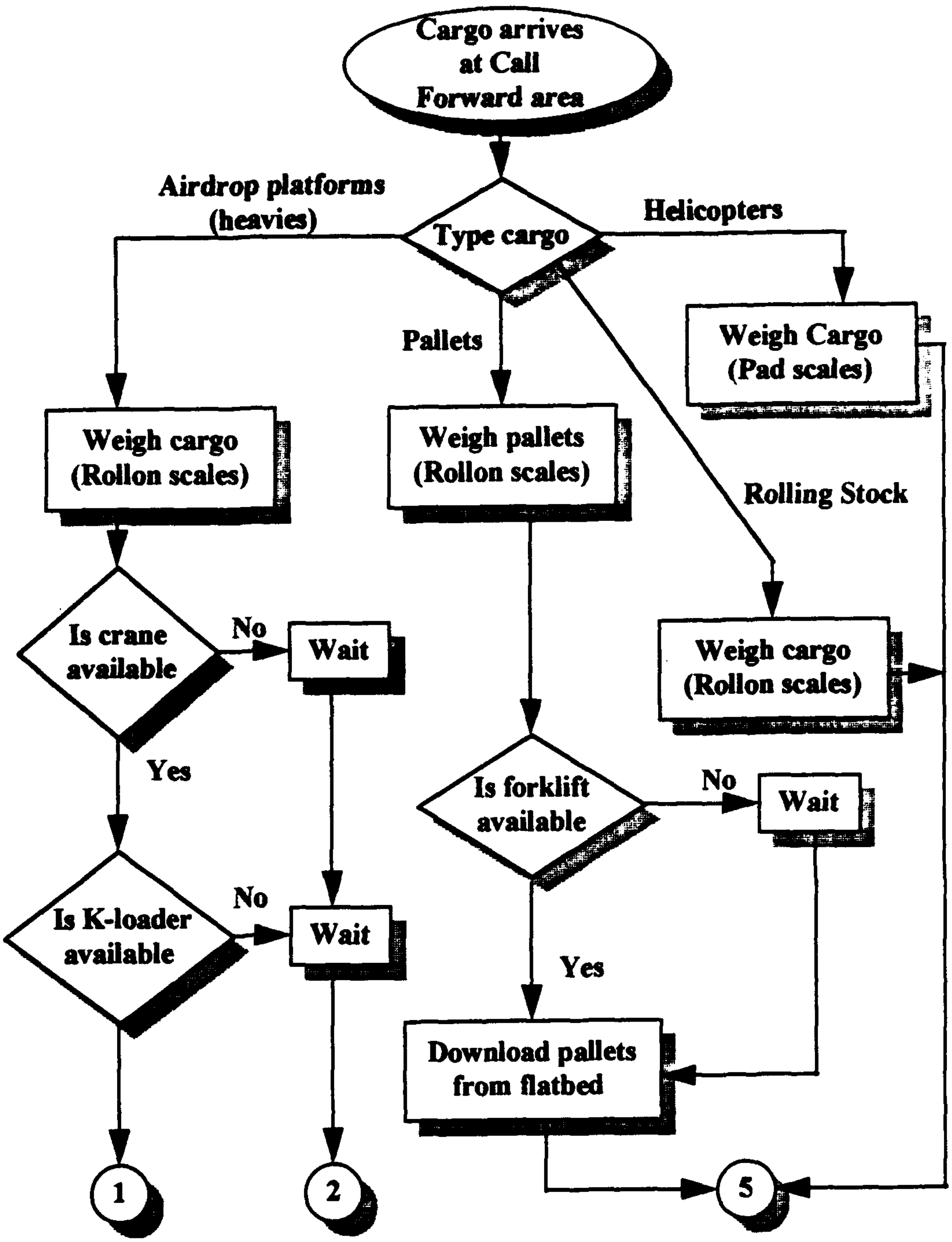
XACT - An abbreviation for a transaction, which in GPSS/H represents a unit of traffic that flows through the model and competes with other transactions for the use of scarce resources.

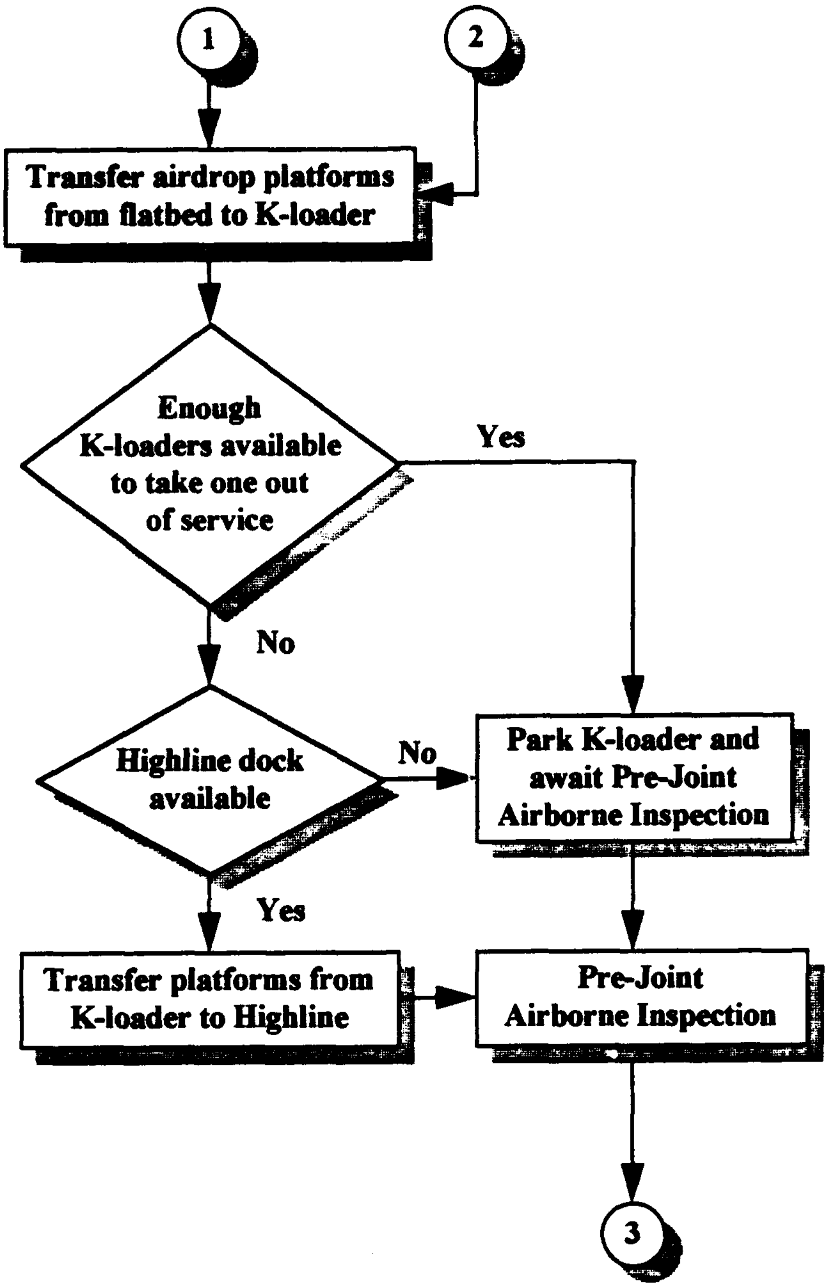
Appendix B: Glossary of Acronyms

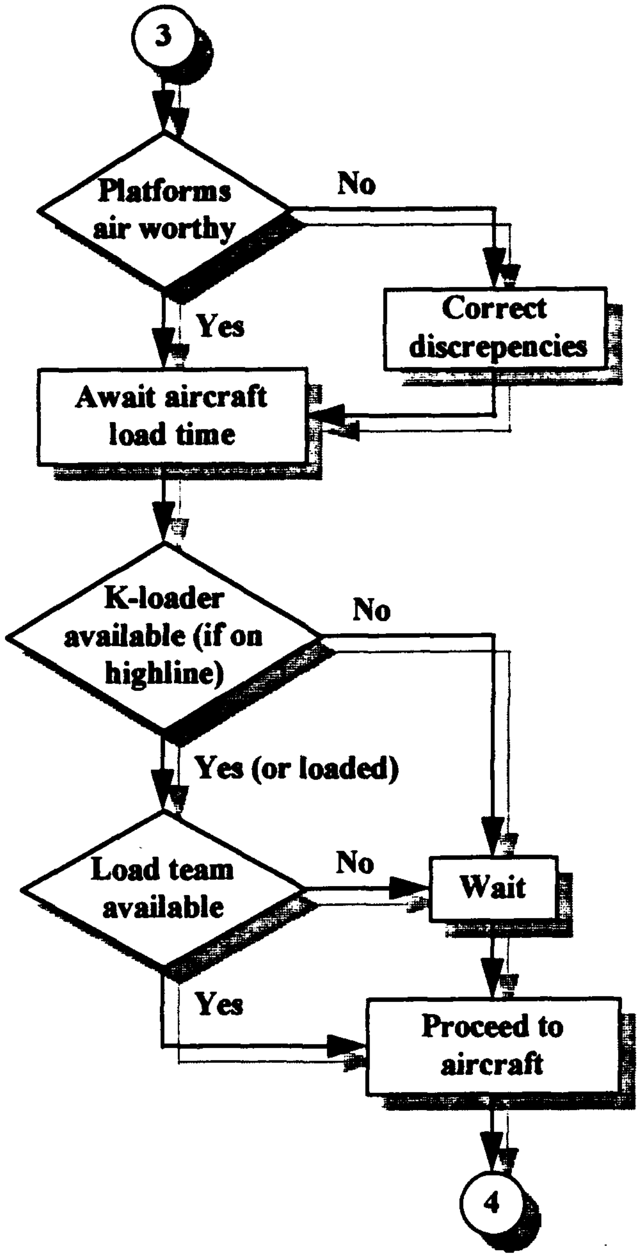
ACC	Air Combat Command
ACRDM	Air Cargo Reception and Distribution Model
ACT	Air Cargo Terminal
AFS	Airlift Flow System
ALM	Aircraft Loading Model
ALOW	Airland Operations Wing
AMC	Air Mobility Command
APOE	Aerial Port of Embarkation
APS	Aerial Port Squadron
APT	Air Passenger Terminal
AOR	Area of Responsibility
CCW	Integrated Operations Concept for Corps Element and Airland Operations Wing
DACG	Departure Airfield Control Group
DRB	Deployment Ready Brigade
EDRE	Emergency Deployment Readiness Exercise
FIREARM	Force Interactive Response Evaluator of Assembly, Replenishment, and Mobility
FORSCOM	Forces Command
GPSS/H	General Purpose Simulation System/H
IMO	Installation Mobility Officer
MCC	Mobility Control Center
MHE	Material Handling Equipment
ORI	Operational Readiness Inspection
PHA	Passenger Holding Area

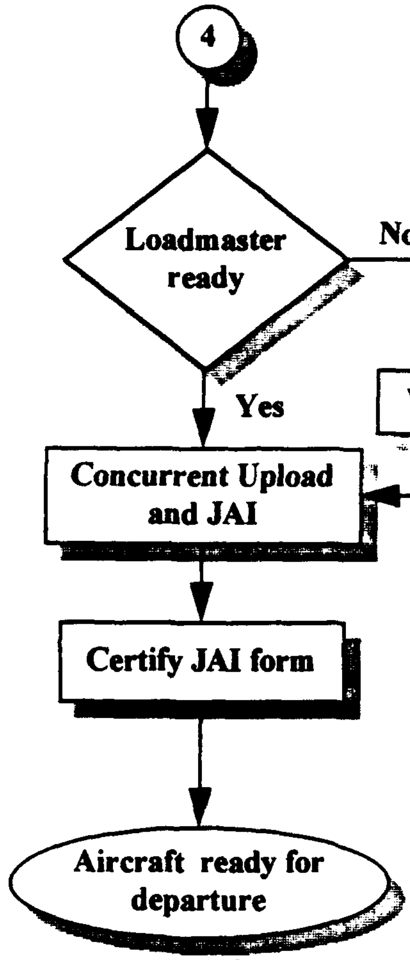
SIGMALOG	Strategic Mobility Scheduling Model
SMCT	Surface Movement and Commercial Terminal
SMOBSBOD	Simulation and Gaming Methods for Analysis of Logistics System
TCU	Transportation Control Unit
TRADOC	Training and Doctrine Command
TRANSCOM	Transportation Command

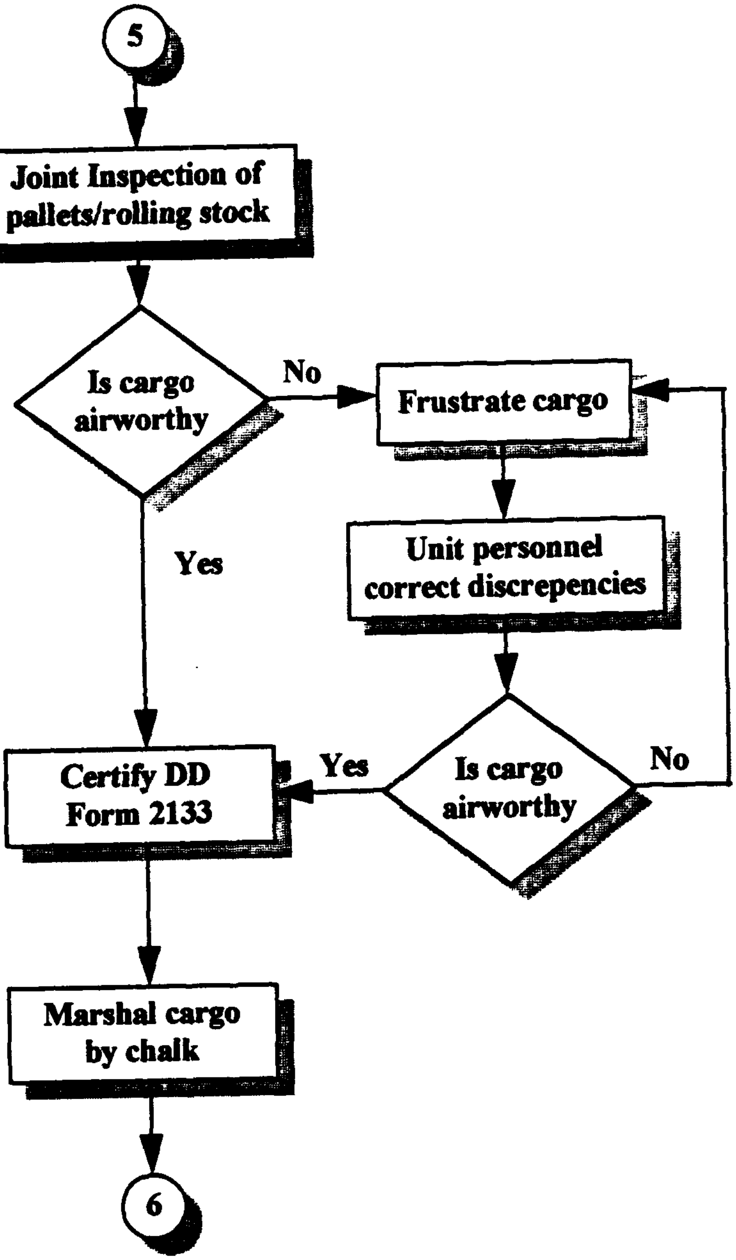
Appendix C: Communicative Deployment Model

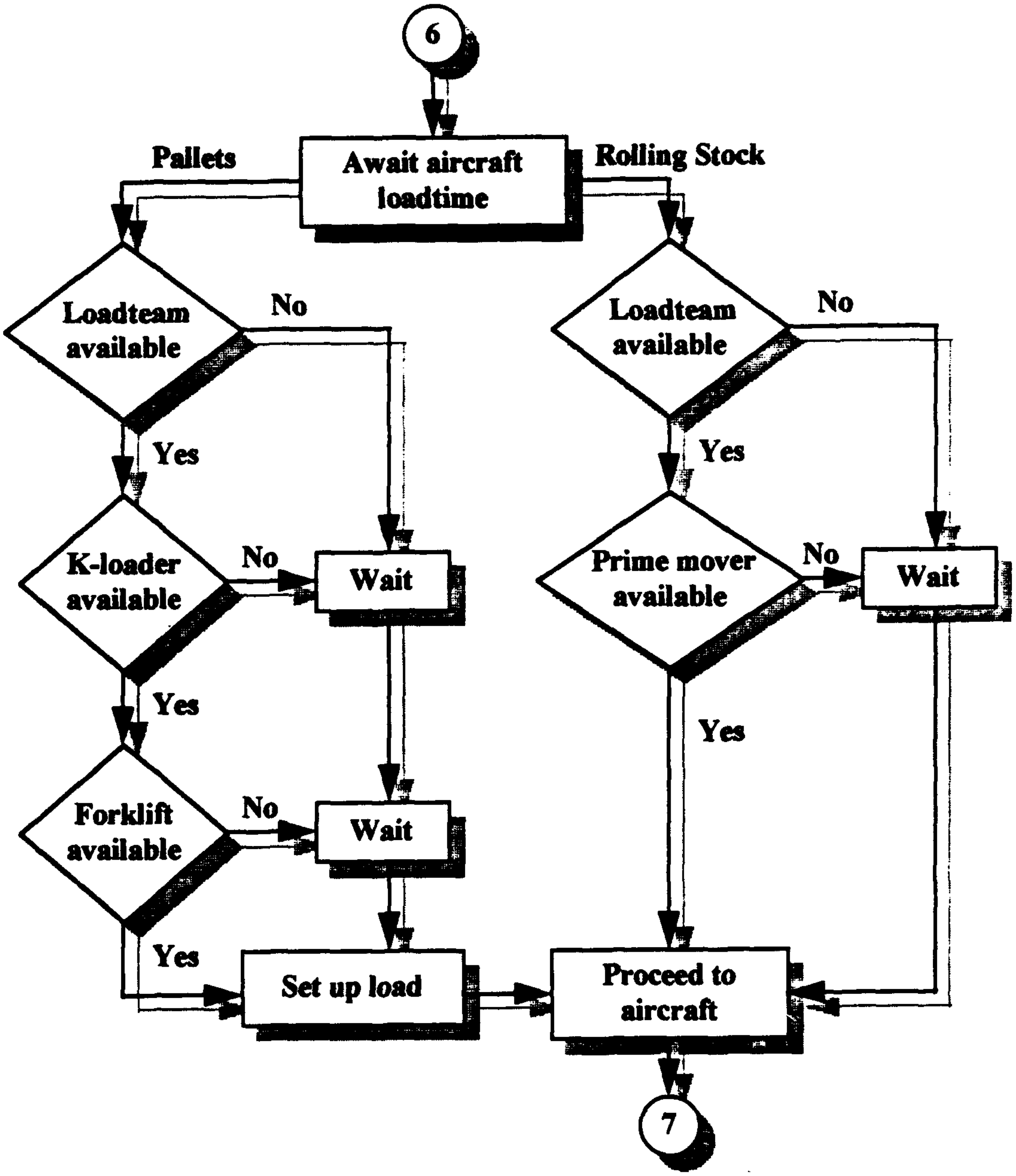


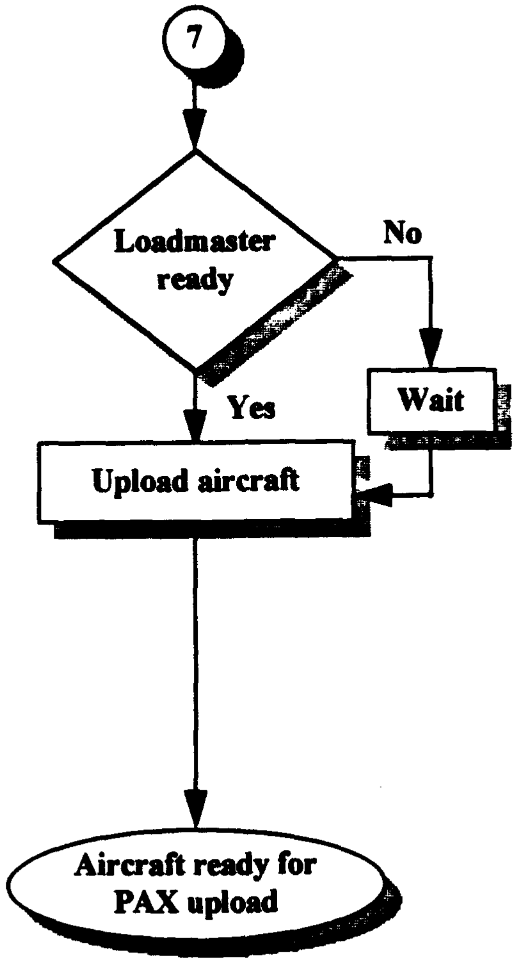

1
2
Transfer airdrop platforms from flatbed to K-loader
Enough K-loaders available to take one out of service
Yes
No
Highline dock available
No
Park K-loader and await Pre-Joint Airborne Inspection
Yes
Transfer platforms from K-loader to Highline
Pre-Joint Airborne Inspection
3

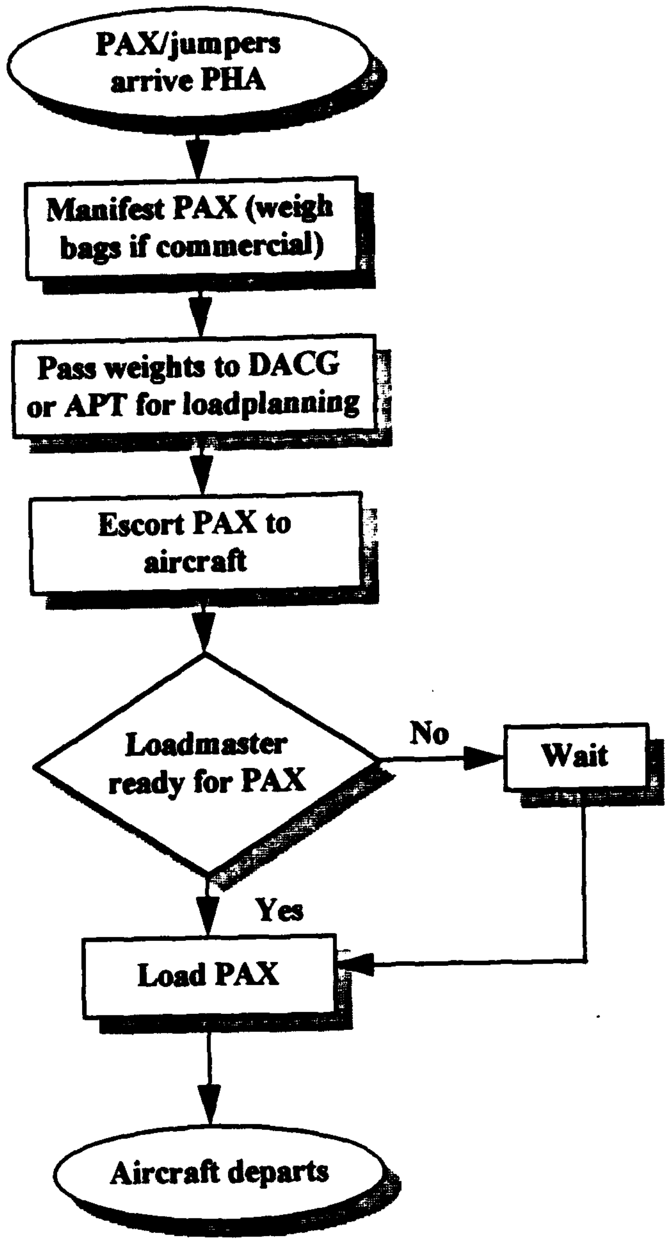

3
Platforms air worthy
No
Correct discrepencies
Yes
Await aircraft load time
K-loader available (if on highline)
No
Yes (or loaded)
Load team available
No
Wait
Yes
Proceed to aircraft
4


4
Loadmaster ready
No
Yes
Wait
Concurrent Upload and JAI
Certify JAI form
Aircraft ready for departure


5
Joint Inspection of pallets/rolling stock
Is cargo airworthy
No
Frustrate cargo
Yes
Unit personnel correct discrepencies
Certify DD Form 2133
Yes
Is cargo airworthy
No
Marshal cargo by chalk
6


6
Pallets
Await aircraft loadtime
Rolling Stock
Loadteam available
No
Yes
K-loader available
No
Wait
Yes
Forklift available
No
Wait
Yes
Set up load
Loadteam available
No
Yes
Prime mover available
No
Wait
Yes
Proceed to aircraft
7


7
Loadmaster ready
No
Wait
Yes
Upload aircraft
Aircraft ready for PAX upload


PAX/jumpers arrive PHA
Manifest PAX (weigh bags if commercial)
Pass weights to DACG or APT for loadplanning
Escort PAX to aircraft
Loadmaster ready for PAX
No
Wait
Yes
Load PAX
Aircraft departs

Appendix D: GPSS/H-Coded Deployment Model

```
*                    DEPLOYMENT SIMULATION MODEL
*                                              Capt Brad Prechtel
*                                              Capt Mark Wingreen
*
          SIMULATE                          Base time unit: 1 minute
          REALLOCATE COM,100000             Increase common storage
          REALLOCATE FAC,100                Increase facilities to 100
          REALLOCATE STO,150                Increase storages to 150
************************************************************************
*         Compiler Directives                                          *
************************************************************************
*
 CHALK    EQU       1,PF           Equivalence statements to define
*                                  X-act parameters
 NOINC    EQU       2,PF
 SERVICE  EQU       3,PF
 ACTYPE   EQU       4,PF
 INCNUMBR EQU       5,PF
 INCTYPE  EQU       6,PF
 WEIGHT   EQU       7,PF
 WTMIN    EQU       8,PF
 WTMAX    EQU       9,PF
 WTMODE   EQU       10,PF
 LTMIN    EQU       11,PF
 LTMAX    EQU       12,PF
 LTMODE   EQU       13,PF
 DEPTIME  EQU       14,PF
 CGOTYPE  EQU       15,PF
 MSN      EQU       16,PF
 KTYPE    EQU       17,PF
 NUMBRKLD EQU       18,PF
 FIRST    EQU       19,PF
 NMBRLNKD EQU       20,PF
 SHUTYPE  EQU       21,PF
 PALPOS   EQU       1,PL
 FRUST    EQU       2,PL
*
          INTEGER   &I,&J          &I and &J are counts used to
*                                  fill matrix PROCTYMS
          INTEGER   &KLODR40       Number of 40K-Loaders available to
*                                  load increments
          INTEGER   &KLODR40S      Number of 40K-Loaders available to
*                                  shuttle increments from scales to
*                                  highlines
          INTEGER   &KLODR25       Number of 25K-Loaders available to
*                                  load increments
          INTEGER   &KLODR25S      Number of 25K-Loaders available to
*                                  shuttle increments from scales to
*                                  highlines
```

```
        INTEGER    &FL10         Number of 10K-Forklifts available
*                                to load increments
        INTEGER    &FL10S        Number of 10K-Forklfts available to
*                                shuttle increments from scales to
*                                highlines
        INTEGER    &DRIVERS      Number of equipment drivers
*                                available
        INTEGER    &LDTEAMS      Number of load teams available
        INTEGER    &LDMAST       Number of loadmaster available
        INTEGER    &JOINT        Number of joint inspectors
*                                available
        INTEGER    &SCALES       Number of scales available
        INTEGER    &ORDERINC     A count to keep track of increment
*                                order
        INTEGER    &FRSTINC      A count to determine the first
*                                increment on a piece of MHE
        INTEGER    &TOTWGHT      A count of the total weight of
*                                increments on a K-loader
        INTEGER    &LOADNUM      Numbers MHE loads
        INTEGER    &CHLK         A count of the current Chalk
        INTEGER    &INCSLNKD     A count of the increments linked on
*                                K-Loader
        INTEGER    &ACC5         Number of C-5 parking spots on ramp
        INTEGER    &ACC141       Number of C-141 parking spots on
*                                ramp
*
        REAL       &TOTLNGTH     A count of the total length of
*                                increments on a K-Loader
        REAL       &ARYARD       Number of pallet positions in Army
*                                marshaling yard
        REAL       &AFYARD       Number of pallet positions in Air
*                                Force marshaling yard
        REAL       &HILINES      Number of pallet positions
*                                available on highlines
*
        LET        &CHLK=8       Set initial value of chalk counter
*                                to 1
        LET        &ORDERINC=1   Set initial value of increment
*                                counter to 1
*
*****************************************************************
*       Control Statements                                      *
*****************************************************************
*
        PUTPIC
0Please enter number of 40K-Loaders available for loading purposes
        GETLIST    &KLODR40
        PUTPIC
0Please enter number of 40K-Loaders available to shuttle incs from scale
        GETLIST    &KLODR40S
        PUTPIC
0Please enter number of 25K-Loaders available for loading purposes
```

```
          GETLIST    &KLODR25
          PUTPIC
0Please enter number of 25K-Loaders available to shuttle incs from scale
          GETLIST    &KLODR25S
          PUTPIC
0Please enter the number of 10K Forklifts available
          GETLIST    &FL10
          PUTPIC
0Please enter number of 10K-Forklifts avail to shuttle incs from scale
          GETLIST    &FL10S
          PUTPIC
0Please enter the number of MHE operators available
          GETLIST    &DRIVERS
          PUTPIC
0Please enter the number of load teams available
          GETLIST    &LDTEAMS
          PUTPIC
0Please enter the number of loadmasters available
          GETLIST    &LDMAST
          PUTPIC
0Please enter the number of joint inspectors available
          GETLIST    &JOINT
          PUTPIC
0Please enter the number of scales available
          GETLIST    &SCALES
          PUTPIC
0Please enter number of pallet positions for the Army marshaling yard
          GETLIST    &ARYARD
          PUTPIC
0Please enter the number of pallet positions for the AF marshaling yard
          GETLIST    &AFYARD
          PUTPIC
0Please enter the number of pallet positions for the highline docks
          GETLIST    &HILINES
          PUTPIC
0Please enter the number of C-5 parking spots available on ramp
          GETLIST    &ACC5
          PUTPIC
0Please enter the number of C-141 parking spots available on ramp
          GETLIST    &ACC141
*
 CHLKFILE FILEDEF    'INFOSIMP.TXT'      Trace file to read in chalk
*                                        number, number of increments in
*                                        chalk, departure time, branch
*                                        of service, and aircraft type
*                                        (THIS FILE CONTAINED ONLY
*                                        AIRDROP LOAD INFORMATION FOR
*                                        SENSITIVITY RUNS)
 INCRFILE FILEDEF    'LDSIMP.TXT'        Trace file to read in increment
*                                        number, increment type, and
*                                        type of cargo (THIS FILE
*                                        CONTAINED ONLY AIRDROP LOAD
```

```
*                                           INFORMATION FOR SENSITIVITY
*                                           RUNS)
 MATRXDAT FILEDEF   'PROCTYM.TXT'           Trace file containing the
*                                           inspection and loading times,
*                                           weight, pallet positions, and
*                                           frustration probabilities for
*                                           each type of increment
 PROCTYMS MATRIX    ML,108,11               Definition statement telling
*                                           the number of rows and columns
*                                           in the increment data matrix
*
          STORAGE   S(KLOAD40),&KLODR40        Define 40K-Loader storage
*                                              and capacity
          STORAGE   S(KLOAD40S),&KLODR40S      Define 40K-Loader shuttle
*                                              storage and capacity
          STORAGE   S(KLOAD25),&KLODR25        Define 25K-Loader storage
*                                              and capacity
          STORAGE   S(KLOAD25S),&KLODR25S      Define 25K-Loader shuttle
*                                              storage and capacity
          STORAGE   S(FL10K),&FL10             Define 10K forklift storage
*                                              and capacity
          STORAGE   S(FL10KS),&FL10S           Define 10K forklift shuttle
*                                              storage and capacity
          STORAGE   S(DRIVER),&DRIVERS         Define driver storage and
*                                              capacity
          STORAGE   S(LDTEAM),&LDTEAMS         Define load team storage
*                                              and capacity
          STORAGE   S(LDMASTER),&LDMAST        Define loadmaster storage
*                                              and capacity
          STORAGE   S(JI),&JOINT               Define joint inspector
*                                              storage and capacity
          STORAGE   S(SCALE),&SCALES           Define scale storage and
*                                              capacity
          STORAGE   S(AMARSH),&ARYARD          Define Call Forward Area
*                                              storage and capacity
          STORAGE   S(AFMARSH),&AFYARD         Define Air Force marshaling
*                                              yard storage and capacity
          STORAGE   S(HILINE),&HILINES         Define highline storage and
*                                              capacity
          STORAGE   S(ACFTC5),&ACC5            Define C-5 aircraft parking
*                                              storage and capacity
          STORAGE   S(ACFTC141),&ACC141        Define C-141 aircraft
*                                              parking storage and
*                                              capacity
          STORAGE   S(1),2                     Define chalk storages and
*                                              capacity, these storages
*                                              will allow only one chalk
*                                              at a time at a particular
*                                              parking spot
          STORAGE   S(2),2
          STORAGE   S(3),2
          STORAGE   S(4),2
```

```
STORAGE     S(5),2
STORAGE     S(6),2
STORAGE     S(7),2
STORAGE     S(8),2
STORAGE     S(9),2
STORAGE     S(10),2
STORAGE     S(11),2
STORAGE     S(12),2
STORAGE     S(13),2
STORAGE     S(14),2
STORAGE     S(15),2
STORAGE     S(16),2
STORAGE     S(17),2
STORAGE     S(18),2
STORAGE     S(19),2
STORAGE     S(20),2
STORAGE     S(21),2
STORAGE     S(22),2
STORAGE     S(23),2
STORAGE     S(24),2
STORAGE     S(25),2
STORAGE     S(26),2
STORAGE     S(27),2
STORAGE     S(28),2
STORAGE     S(29),2
STORAGE     S(30),2
STORAGE     S(31),2
STORAGE     S(32),2
STORAGE     S(33),2
STORAGE     S(34),2
STORAGE     S(35),2
STORAGE     S(36),2
STORAGE     S(37),2
STORAGE     S(38),2
STORAGE     S(39),2
STORAGE     S(40),2
STORAGE     S(41),2
STORAGE     S(42),2
STORAGE     S(43),2
STORAGE     S(44),2
STORAGE     S(45),2
STORAGE     S(46),2
STORAGE     S(47),2
STORAGE     S(48),2
STORAGE     S(49),2
STORAGE     S(50),2
STORAGE     S(51),2
STORAGE     S(52),2
STORAGE     S(53),2
STORAGE     S(54),2
STORAGE     S(55),2
STORAGE     S(56),2
```

```
STORAGE      S(57),2
STORAGE      S(58),2
STORAGE      S(59),2
STORAGE      S(60),2
STORAGE      S(61),2
STORAGE      S(62),2
STORAGE      S(63),2
STORAGE      S(64),2
STORAGE      S(65),2
STORAGE      S(66),2
STORAGE      S(67),2
STORAGE      S(68),2
STORAGE      S(69),2
STORAGE      S(70),2
STORAGE      S(71),2
STORAGE      S(72),2
STORAGE      S(73),2
STORAGE      S(74),2
STORAGE      S(75),2
STORAGE      S(76),2
STORAGE      S(77),2
STORAGE      S(78),2
STORAGE      S(79),2
STORAGE      S(80),2
STORAGE      S(81),2
STORAGE      S(82),2
STORAGE      S(83),2
STORAGE      S(84),2
STORAGE      S(85),2
STORAGE      S(86),2
STORAGE      S(87),2
STORAGE      S(88),2
STORAGE      S(89),2
STORAGE      S(90),2
STORAGE      S(91),2
STORAGE      S(92),2
STORAGE      S(93),2
STORAGE      S(94),2
STORAGE      S(95),2
STORAGE      S(96),2
STORAGE      S(97),2
STORAGE      S(98),2
STORAGE      S(99),2
STORAGE      S(100),2
STORAGE      S(101),2
STORAGE      S(102),2
STORAGE      S(103),2
STORAGE      S(104),2
STORAGE      S(105),2
STORAGE      S(106),2
STORAGE      S(107),2
STORAGE      S(108),2
```

```
            STORAGE    S(109),2
            STORAGE    S(110),2
            STORAGE    S(111),2
            STORAGE    S(112),2
            STORAGE    S(113),2
            STORAGE    S(114),2
            STORAGE    S(115),2
            STORAGE    S(116),2
            STORAGE    S(117),2
            STORAGE    S(118),2
            STORAGE    S(119),2
            STORAGE    S(120),2
            STORAGE    S(121),2
            STORAGE    S(122),2
            STORAGE    S(123),2
            STORAGE    S(124),2
            STORAGE    S(125),2
            STORAGE    S(126),2
            STORAGE    S(127),2
            STORAGE    S(128),2
            STORAGE    S(129),2
            STORAGE    S(130),2
            STORAGE    S(131),2
            STORAGE    S(132),2
            STORAGE    S(133),2
            STORAGE    S(134),2
            STORAGE    S(135),2
*
 FULL25K   BVARIABLE  &TOTWGHT'LE'25000*_             Boolean variable to
                      &TOTLNGTH'LE'3*SNF(KLOAD25)     determine if 25K-
*                                                     Loader is full and if
*                                                     one is available
 FULL25KS  BVARIABLE  PF(WEIGHT)'LE'25000*_           Boolean variable to
                      PL(PALPOS)'LE'3*_               determine if shuttle
                      SNF(KLOAD25S)                   25K-Loader is
*                                                     available and if
*                                                     increment will fit
 FULL40K   BVARIABLE  &TOTWGHT'LE'40000*_             Boolean variable to
                      &TOTLNGTH'LE'5                  determine if 40K-
*                                                     Loader is full or not
 FULL10K   BVARIABLE  &TOTWGHT'LE'10000*_             Boolean variable to
                      &TOTLNGTH'LE'1.2*SNF(FL10K)     determine if
*                                                     increment will fit on
*                                                     a 10K-Forklift and if
*                                                     one is available
 FULL10KS  BVARIABLE  PF(WEIGHT)'LE'10000*_           Boolean variable to
                      PL(PALPOS)'LE'1.2*_             determine if
                      SNF(FL10KS)                     increment will fit
*                                                     on a shuttle 10K-
*                                                     Forklift and if one
*                                                     is available
 CHOOSE    BVARIABLE  PF(WEIGHT)<=25000*_             Boolean variable to
```

```
                 PL(PALPOS)<=3*(SNF(KLOAD25)_  determine if
                 +W(LEAD25)=1)                 increment will fit on
*                                              a 25K-Loader
 MHEAVAIL BVARIABLE ((SNF(KLOAD25)*PF(WEIGHT)_ Boolean variable to
                 <=25000*PL(PALPOS)<=3)_       determine if any MHE
                 +(SNF(KLOAD40)))*_            is available
                 (PF(INCNUMBR)=&ORDERINC)
*
          GETLIST FILE=MATRXDAT,_              Load matrix file into
                 ((ML$PROCTYMS(&I,&J),_        the computer model
                 &J=1,11),&I=1,108)
*
***************************************************************************
*   Model Segment 1 (Generate Chalks/Aircraft Assigning Parameters)      *
***************************************************************************
*
          GENERATE  15,,,51,,21PF,2PL        Chalks/aircraft arrive
*                                            into model every 15
*                                            minutes to limit the
*                                            number of X-acts in
*                                            existence at any one
*                                            time, a total of 51
*                                            airland chalks are
*                                            created (ONCE THE REST OF
*                                            THE MODEL IS COMPLETED
*                                            THIS NUMBER NEEDS TO BE
*                                            SET AT 132)
          BGETLIST  FILE=CHLKFILE,_          Assign chalk number,
                    (PF(CHALK),_             mission number, number of
                    PF(MSN),PF(NOINC),_      increments, departure
                    PF(DEPTIME),PF(SERVICE),_  time branch of service,
                    PF(ACTYPE))                and aircraft type
          TEST LE   AC1,PF(DEPTIME)-720,_    If scheduled scale time,
                    TIMETOGO                 proceed, if not..
          ADVANCE   PF(DEPTIME)-720-AC1      Wait until scheduled time
 TIMETOGO SPLIT     PF(NOINC),ASSTYPE        Split chalk into number
*                                            of increments, first/lead
*                                            X-act falls through
          TERMINATE 0                        First X-act destroyed
*
 ASSTYPE  BGETLIST  FILE=INCRFILE,_          Assign increment number
                    (PF(INCNUMBR),_          and type
                    PF(INCTYPE))
*
          ASSIGN    WEIGHT,ML(PROCTYMS,_     Assign increment weight
                    PF(INCTYPE),2),PF        from matrix value
          ASSIGN    PALPOS,ML(PROCTYMS,_     Assign pallet positions
                    PF(INCTYPE),3),PL        required from matrix
*                                            value
          ASSIGN    WTMIN,ML(PROCTYMS,_      Assign minimum weighing
                    PF(INCTYPE),4),PF        time from matrix value
          ASSIGN    WTMAX,ML(PROCTYMS,_      Assign maximum weighing
```

```
              PF(INCTYPE),5),PF        time from matrix value
     SSIGN    WTMODE,ML(PROCTYMS,_     Assign mode weighing
              PF(INCTYPE),6),PF        time from matrix value
     ASSIGN   LTMIN,ML(PROCTYMS,_      Assign minimum loading
              PF(INCTYPE),7),PF        time from matrix value
     ASSIGN   LTMAX,ML(PROCTYMS,_      Assign maximum loading
              PF(INCTYPE),8),PF        time from matrix value
     ASSIGN   LTMODE,ML(PROCTYMS,_     Assign mode loading time
              PF(INCTYPE),9),PF        from matrix value
     ASSIGN   CGOTYPE,ML(PROCTYMS,_    Assign cargo or load type
              PF(INCTYPE),10),PF       from matrix  value
*                                      (1=pallet, 2=rolling
*                                      stock, 3=airdrop,
*                                      4=passengers)
     ASSIGN   FRUST,ML(PROCTYMS,_      Assign frustration proba-
              PF(INCTYPE),11),PL       bility from matrix  value
*
     TEST E   PF(SERVICE),300,WAA      Army loads fall through,
*                                      Air Force loads sent to
*                                      Air Force model segment
     TEST NE  PF(CGOTYPE),4,GOOD       Passenger loads are sent
*                                      to GATHER statement for
*                                      further movement to Army
*                                      passenger processing
*                                      model segment
*
     TEST E   PF(CGOTYPE),3,AIRLAND    Airdrop loads fall
*                                      through, airland loads
*                                      sent to another segment
*
**************************************************************************
*        Army Airdrop Highline and K-Loader Selection Model Segement *
**************************************************************************
*
     TEST E   BV(FULL10KS),1,SHU25K    If it will fit on a
*                                      10K-Forklift, then fall
*                                      through
     ENTER    FL10KS                   Get shuttle 10K-Forklift
     ASSIGN   SHUTYPE,10,PF            Mark increment as going
*                                      on a shuttle 10K-Forklift
     TRANSFER ,SCALETYM
SHU25K TEST E BV(FULL25KS),1,SHU40K    If it will fit on a
*                                      25K-Loader, then fall
*                                      through
     ENTER    KLOAD25S                 Get a shuttle 25K-Loader
     ASSIGN   SHUTYPE,25,PF            Mark it as going on a
*                                      shuttle 25K-Loader
     TRANSFER ,SCALETYM
SHU40K ENTER  KLOAD40S                 Get a shuttle 40K-Loader
     ASSIGN   SHUTYPE,40,PF            Mark it as going on a
*                                      shuttle 40K-Loader
SCALETYM ENTER DRIVER                  Get a driver
```

```
          ENTER      SCALE                     Seize the scale
          ENTER      LDMASTER                  Get a loadmaster
          ADVANCE    RVTRI(2,PF(WTMIN),_       Weigh, JAI, and place
                     PF(WTMODE),PF(WTMAX))     increment on MHE
          LEAVE      LDMASTER                  Release loadmaster
          LEAVE      SCALE                     Release scale
          TRANSFER   .(1000-PL(FRUST)*1000),,OK1  Proportion of
*                                                 increments are
*                                                 frustrated
          LEAVE      DRIVER                    Release driver while
*                                              increment discrepancy is
*                                              corrected
          ADVANCE    10,5                      Correct discrepancies
          ENTER      DRIVER                    Get a driver
OK1       ADVANCE    4,1                       Time to move from scales
*                                              to highlines or staging
*                                              area
          TEST E     PF(SHUTYPE),10,REL25KS    If on a shuttle 10K-Fork_
*                                              lift, then send through
          ENTER      HILINE,PL(PALPOS)+.55     Take up highline space
          LEAVE      DRIVER                    Release MHE driver
          LEAVE      FL10KS                    Release shuttle 10K-
*                                              Forklift
          TRANSFER   ,HIGATHER
REL25KS   TEST E     PF(SHUTYPE),25,REL40KS    If on a shuttle 25K-
*                                              Loader, then send through
          ENTER      HILINE,PL(PALPOS)+.55     Take up highline space
          LEAVE      DRIVER                    Release MHE driver
          LEAVE      KLOAD25S                  Release shuttle 25K-Ldr
          TRANSFER   ,HIGATHER
REL40KS   ENTER      HILINE,PL(PALPOS)+.55     Take up highline space
          LEAVE      DRIVER                    Release MHE driver
          LEAVE      KLOAD40S                  Release shuttle 40K-Ldr
HIGATHER  PRIORITY   1                         Increase priority to 1
          GATHER     PF(NOINC)                 Wait until entire chalk
*                                              is on highlines
          TEST NE    PF(INCNUMBR),1,MHESEL     Test if its the first
*                                              increment for chalk
          LINK       CHALKNO,(INCNUMBR)PF      If not, link on user
*                                              chain in increasing
*                                              increment order
MHESEL    PRIORITY   PR,BUFFER                 Delay lead increment
          TEST LE    AC1,PF(DEPTIME)-175,SET   Determine if it is time
*                                              to remove piece from
*                                              highline and transfer
*                                              to a K-Loader
          ADVANCE    PF(DEPTIME)-175-AC1       If not, wait until load
*                                              set-up time
SET       GATE LR    NEXTCHLK                  Only let one chalk into
*                                              the MHE selection segment
*                                              at one time
          LOGIC S    NEXTCHLK                  Set switch for above gate
```

```
         UNLINK E    CHALKNO,MHESEL2,ALL,_     Unlink all increments
                     (CHALK)PF,PF(CHALK)       from the chalk, will come
*                                              off in increasing
*                                              increment number order
 MHESEL2 TEST E      BV(MHEAVAIL),1            Ensures adequate MHE is
*                                              available before pulling
*                                              increments off the
*                                              highline
         BLET        &ORDERINC=&ORDERINC+1     Increase increment count
*                                              by 1
         TEST E      PF(INCNUMBR),1,SAMECHLK   If it's the first
*                                              increment from a new
*                                              chalk,
*                                              then fall through, if not
*                                              send to SAMECHALK
         TRANSFER    ,GONEWKLD
*
* The following segment sends any increment small enough to fit on a
* 25K-Loader to seize one as long as one is available.  Increments
* requiring a 40K-Loader are sent to get one, the GOTO40K GATE ensures
* suceeding increments will follow.  The FULL GATE is set to allow
* increments loading on the last K-Loader to proceed.
*
SAMECHLK GATE LR     GOTO40K,FILL40K           If logic switch is reset,
*                                              send increment through
         TEST E      BV(CHOOSE),0,FILL25K      If it won't fit on 25K-
*                                              Loader, send through
         TEST NE     PF(INCNUMBR),1,PROCEED    If its the first
*                                              increment of chalk, send
*                                              through
         LOGIC S     FULL                      Set logic switch
PROCEED  LOGIC S     GOTO40K                   Set logic switch
         TRANSFER    ,FILL40K
*
FILL25K  BLET        &FRSTINC=&FRSTINC+1       Increase K-Loader
*                                              increment counter by 1
         BLET        &TOTWGHT=&TOTWGHT+_       Add increment's weight to
                     PF(WEIGHT)                total weight
         BLET        &TOTLNGTH=&TOTLNGTH+_     Add increment's length to
                     PL(PALPOS)                total length
         TEST NE     &FRSTINC,1,GET25K         If its not the first
*                                              increment on K-Loader,
*                                              send through
         TEST E      BV(FULL25K),1,GONEWKLD    If it will fit on a 25K-
*                                              Loader, then send through
         BLET        &INCSLNKD=&INCSLNKD+1     Increase counter of
*                                              increments linked by 1
         ASSIGN      KTYPE,25,PF               Mark increment as going
*                                              on a 25K-Loader
         ASSIGN      NUMBRKLD,&LOADNUM,PF      Assign K-Loader number
*                                              for unlinking purposes
         PRIORITY    2                          Increase priority to 2
```

```
          TEST E      PF(NOINC),PF(INCNUMBR),_   If the last increment in
                      WAIT25K                    chalk, then send through
          LOGIC S     FULL                      Set logic switch
          PRIORITY    PR,BUFFER                 Delay increment
          BLET        &TOTWGHT=0                Reset weight ampervari-
*                                               able to 0
          BLET        &TOTLNGTH=0               Reset length ampervari-
*                                               able to 0
          BLET        &FRSTINC=0                Reset K-Loader increment
*                                               counter to 0
          LOGIC R     GOTO40K                   Reset logic switch
 WAIT25K  GATE LS     FULL                      If logic switch is set,
*                                               then send through
          ASSIGN      NMBRLNKD,&INCSLNKD,PF     Assign increments linked
*                                               count number
          TEST E      PF(NOINC),PF(INCNUMBR),_   If its the last inc,
                      NEXT25                     fall through
          BLET        &ORDERINC=1               Set increment order
*                                               counter to 1
          BLET        &INCSLNKD=0               Reset increments linked
*                                               counter to 0
          LOGIC R     FULL                      Reset logic switch
          LEAVE       HILINE,PL(PALPOS)+.55     Release highline space
          LOGIC R     NEXTCHLK                  Reset gate to let next
*                                               chalk into MHE selection
*                                               segment
          PRIORITY    3                         Increase priority to 3
 NEXT25   LINK        NUMBERK,FIFO              Put on K-Loader user
*                                               chain
*
 GET25K   TEST NE     PF(NOINC),PF(INCNUMBR),_   If not last increment,
                      GONEWKLD                   then fall through
          LOGIC R     FULL                      Reset logic switch
          BLET        &LOADNUM=&LOADNUM+1       Increase K-Loader counter
*                                               by 1
          ENTER       KLOAD25                   Need a 25K-Loader
          ASSIGN      KTYPE,25,PF               Mark increment as going
*                                               on a 25K-Loader
          ASSIGN      NUMBRKLD,&LOADNUM,PF      Assign K-Loader number
*                                               for unlinking purposes
 LEAD25   PRIORITY    2                         Increase priority to 2
          GATE LS     FULL                      Lets increments through
*                                               when logic switch is set
          TRANSFER    ,LASTSET
*
 FILL40K  GATE LR     GOINKLDR                  Lets increments through
*                                               when logic switch reset
          BLET        &FRSTINC=&FRSTINC+1       Counter for number of
*                                               increments on K-Loader
          BLET        &TOTWGHT=&TOTWGHT+_       Add increment's weight
                      PF(WEIGHT)                to total weight
```

```
            BLET        &TOTLNGTH=&TOTLNGTH_           Add increment's length
                        PL(PALPOS)                     to total length
            TEST NE     &FRSTINC,1,GET40K              If its not the first
                                                       increment on K-Loader,
*                                                      then fall through
*
            TEST E      BV(FULL40K),1,GONEWKLD         If it won't fit on same
                                                       40K-Loader, try new MHE
*
            BLET        &INCSLNKD=&INCSLNKD+1          Increase increments
                                                       linked counter by 1
*
            ASSIGN      KTYPE,40,PF                    Mark increment as going
                                                       on a 40K-Loader
*
            ASSIGN      NUMBRKLD,&LOADNUM,PF           Assign K-Loader number
                                                       for unlinking purposes
*
            PRIORITY    2                              Increase priority to 2
            TEST E      PF(NOINC),PF(INCNUMBR),_        If its last increment on
                        WAIT40K                         chalk, send through
            LOGIC S     GOINKLDR                       Set logic switch
            LOGIC S     FULL                           Set logic switch
            PRIORITY    PR,BUFFER                      Delay increment
            BLET        &TOTWGHT=0                     Reset weight ampervari-
                                                       able to 0
*
            BLET        &TOTLNGTH=0                    Reset length ampervari-
                                                       able to 0
*
            BLET        &FRSTINC=0                     Reset K-Loader increment
                                                       counter to 0
*
            LOGIC R     GOTO40K                        Reset logic switch
            LOGIC R     GOINKLDR                       Reset logic switch
WAIT40K     GATE LS     FULL                           Let incs through when
                                                       logic switch is set
*
            ASSIGN      NMBRLNKD,&INCSLNKD,PF          Assign inc count number
            TEST E      PF(NOINC),PF(INCNUMBR),_        If its the last inc on
                        NEXT40                          K-Loader send through
            BLET        &ORDERINC=1                    Reset increment order
                                                       counter to 1
*
            BLET        &INCSLNKD=0                    Reset increments linked
                                                       counter to 0
*
            LOGIC R     FULL                           Reset logic switch
            LOGIC R     GOINMHE                        Reset logic switch
            LEAVE       HILINE,PL(PALPOS)+.55          Release highline space
            LOGIC R     NEXTCHLK                       Reset logic switch so
                                                       next chalk can enter MHE
*                                                      selection segment
*
            PRIORITY    3                              Increase priority to 3
NEXT40      LINK        NUMBERK,FIFO                   Place on K-Loader user
                                                       chain
*
GET40K      TEST NE     PF(NOINC),PF(INCNUMBR),_        If its not the last
                        GONEWKLD                        increment,send through
            LOGIC R     FULL                           Reset logic switch
            BLET        &LOADNUM=&LOADNUM+1            Increase K-Loader counter
                                                       by one
*
            ENTER       KLOAD40                        Get 40K-Loader
            ASSIGN      KTYPE,40,PF                    Mark increment as going
```

```
*                                             on a 40K-Loader
          ASSIGN     NUMBRKLD,&LOADNUM,PF     Assign K-Loader number
*                                             for unlinking purposes
          PRIORITY   2                        Increase priority to 2
          GATE LS    FULL                     Let increments through
*                                             when logic switch is set
          TRANSFER   ,LASTSET
*
 GONEWKLD PRIORITY   2                        Increase priority to 2
          LOGIC S    GOINKLDR                 Set logic switch
          LOGIC S    FULL                     Set logic switch
          PRIORITY   PR,BUFFER                Delay increment
          BLET       &INCSLNKD=0              Reset incs linked to 0
          BLET       &TOTWGHT=0               Reset weight ampervari-
*                                             able to 0
          BLET       &TOTLNGTH=0              Reset length ampervari-
*                                             able to 0
          BLET       &FRSTINC=0               Reset K-Loader increment
*                                             counter to 0
          LOGIC R    GOTO40K                  Reset logic switch
          LOGIC R    FULL                     Reset logic switch
          LOGIC R    GOINKLDR                 Reset logic switch
          TEST E     PF(NOINC),PF(INCNUMBR),_  If its only increment or
                     SAMECHLK                  last increment on chalk,
*                                              then fall through
          LOGIC R    NEXTCHLK                 Reset logic switch so
*                                             next chalk can enter MHE
*                                             selection segment
          BLET       &ORDERINC=1              Reset increment order
*                                             counter to one
          BLET       &LOADNUM=&LOADNUM+1      Increase K-loader counter
*                                             by 1
          BLET       &TOTWGHT=&TOTWGHT+_      Add incs's weight to
                     PF(WEIGHT)               total weight
          BLET       &TOTLNGTH=&TOTLNGTH+_    Add inc's length to total
                     PL(PALPOS)               length
          TEST E     BV(FULL10K),1,TRY25K     Test to see if it will
                     PL(PALPOS)               fit on a 10K forklift
          ENTER      FL10K                    Enter forklift storage
          ASSIGN     KTYPE,10,PF              Mark increment as going
*                                             on a 10K-Forklift
          TRANSFER   ,LASTSET
 TRY25K   TEST E     BV(FULL25K),1,TRY40K     Test if it will fit on a
*                                             25K-Loader
          ENTER      KLOAD25                  Get 25K-Loader
          ASSIGN     KTYPE,25,PF              Mark increment as going
*                                             on a 25K-Loader
          ASSIGN     NUMBRKLD,&LOADNUM,PF     Assign K-Loader number
*                                             for unlinking purposes
          TRANSFER   ,LASTSET
 TRY40K   ENTER      KLOAD40                  Get 40K-Loader
          ASSIGN     KTYPE,40,PF              Mark increment as going
```

```
*                                           on a 40K-Loader
          ASSIGN    NUMBRKLD,&LOADNUM,PF    Assign K-Loader number
*                                           for unlinking purposes
LASTSET   ASSIGN    NMBRLNKD,&INCSLNKD,PF   Assign increment linked
                                            count number
          BLET      &TOTWGHT=0              Reset weight ampervari-
*                                           able to 0
          BLET      &TOTLNGTH=0             Reset length ampervari-
*                                           able to 0
          BLET      &FRSTINC=0              Reset K-Loader increment
*                                           counter to 0
          ASSIGN    FIRST,1,PF              Assign parameter to mark
*                                           increment as the first on
*                                           the MHE
          PRIORITY  PR,BUFFER               Hold lead increment until
*                                           others can be linked
          BLET      &INCSLNKD=0             Reset linked count to 0
          PRIORITY  3                       Increase priority to 3
          ENTER     DRIVER                  Get an MHE driver
          ADVANCE   5,1                     Push from highline to
*                                           K-Loader
          LEAVE     HILINE,PL(PALPOS)+.55   Release highline space
          TEST LE   AC1,PF(DEPTIME)-140,_   If its not time to load
                    LDTIME                  increment, fall through
          LEAVE     DRIVER                  Release MHE driver
          ADVANCE   PF(DEPTIME)-140-AC1     Wait until load time
          ENTER     DRIVER                  Seize MHE driver
          TEST NE   PF(NMBRLNKD),0,HOLD     If increment has others
*                                           linked with it, then it
*                                           falls through
LDTIME    TRANSFER  BOTH,LINE5,LINE6        Send to open path
LINE5     SEIZE     GETINCS5                Seize unlinking path
*                                           segment
TRYAGAN5  UNLINK E  NUMBERK,UPPRIOR5,ALL,_  Remove increments from
                    (NUMBRKLD)PF,PF(NUMBRKLD) K-Loader user chain
UPPRIOR5  PRIORITY  6                       Increase priority to 6
          TEST E    PF(FIRST),1,GOWAIT5     If its the lead increment
*                                           on a K-Loader, then fall
*                                           through
          PRIORITY  PR,BUFFER               Delay increment
          TEST NE   W(GOWAIT5),PF(NMBRLNKD),_ If all linked
                    GOWAIT5                   increments are waiting
*                                           in block GOWAIT5, then
*                                           send lead increment there
          ADVANCE   1                       Wait one minute before
*                                           sending to unlink block
          TRANSFER  ,TRYAGAN5               Send lead increment to
*                                           unlink block
GOWAIT5   GATHER    PF(NMBRLNKD)+1          Hold until all increments
*                                           for K-Loader are ready
          TEST E    PF(FIRST),1,HOLD        Send lead increment
*                                           through
```

```
         RELEASE    GETINCS5                        Release increment
*                                                   unlinking path for next
*                                                   K-Loader
         TRANSFER   ,HOLD                           Send to wait for entire
*                                                   chalk
LINE6    SEIZE      GETINCS6                        Seize unlinking path
*                                                   segment
TRYAGAN6 UNLINK E   NUMBERK,UPPRIOR6,ALL,_            Remove increments from
                    (NUMBRKLD)PF,PF(NUMBRKLD)       K-Loader user chain
UPPRIOR6 PRIORITY   6                               Increase priority to 6
         TEST E     PF(FIRST),1,GOWAIT6             If its the lead increment
*                                                   then send through
         PRIORITY   PR,BUFFER                       Delay lead increment
         TEST NE    W(GOWAIT6),PF(NMBRLNKD),_         If all linked
                    GOWAIT6                           increments are waiting
*                                                   in block GOWAIT6, then
*                                                   send lead increment there
         ADVANCE    1                               Wait one minute before
*                                                   sending to unlink block
         TRANSFER   ,TRYAGAN6                       Send lead increment to
*                                                   unlink block
GOWAIT6  GATHER     PF(NMBRLNKD)+1                  Hold until all increments
*                                                   for K-Loader are ready
         TEST E     PF(FIRST),1,HOLD                Send lead increment
*                                                   through
         RELEASE    GETINCS6                        Release increment
*                                                   unlinking path for next
*                                                   K-Loader
HOLD     GATHER     PF(NOINC)                       Hold until all increments
*                                                   are ready for upload
         TEST E     PF(FIRST),0,KLINK               If not the lead
*                                                   increment, send through
         PRIORITY   8                               Increase priority to 8
         LINK       NUMBERK,FIFO                    Put back on K-Loader
*                                                   user chain
KLINK    PRIORITY   7                               Increase priority to 7
         TEST NE    PF(INCNUMBR),1,SELACFT          Send first increment of
*                                                   chalk to aircraft, rest
*                                                   fall through
         LINK       CHALKNO,FIFO                    Put on chalk user chain
SELACFT  ADVANCE    8,2                             Time to drive MHE to
*                                                   aircraft parking spot
         TRANSFER   ,LOADC141                       Transfer to the C-141
*                                                   aircraft loading model
*                                                   segment
*
*************************************************************************
*        Army Airland Load Processing Model Segment                     *
*************************************************************************
AIRLAND  PRIORITY   5                               Increase priority so
*                                                   that all cargo is
*                                                   loaded before PAX
```

```
          ENTER       SCALE                       Seize one of the roll-
*                                                 on scales
          ENTER       JI                          Seize one of the joint
*                                                 inspectors
          ADVANCE     RVTRI(4,PF(WTMIN),_         Weigh and inspect cargo
                      PF(WTMODE),PF(WTMAX))
          LEAVE       SCALE                       Release Roll-on scale
          LEAVE       JI                          Release joint inspector
          TRANSFER    .(1000-PL(FRUST)*1000)_     Proportion are frustrated
                      ,,GOOD
          ADVANCE     25,20                       Time to correct problems
 GOOD     ADVANCE     3                           Move to chalk assembly
*                                                 area
          ENTER       AMARSH,PL(PALPOS)           Go in chalk assembly area
          GATHER      PF(NOINC)                   Hold until all increments
*                                                 are present
          TEST LE     AC1,PF(DEPTIME)-210,_       Determine if its load
                      READY                       set-up time
          ADVANCE     PF(DEPTIME)-210-AC1         If not, wait until
*                                                 load set-up time
 READY    TEST NE     PF(CGOTYPE),4,APAX          Send passenger increments
*                                                 to Army passenger
*                                                 processing segment
          TEST E      PF(CGOTYPE),1,RS            If pallet, fall through
*
          TERMINATE   0                           DUMMY TERMINATE BLOCK
*                                                 THE MHE SELECTION SEGMENT
*                                                 NEEDS TO BE ADDED
*
*************************************************************************
*         Army Passenger Processing Model Segment                       *
*************************************************************************
*
 APAX     TERMINATE   0                           DUMMY TERMINATE BLOCK
*                                                 THIS SECTION NEEDS TO
*                                                 BE COMPLETED
*
*************************************************************************
*         Air Force Load Processing Model Segment                       *
*************************************************************************
*
 WAA      TEST NE     PF(CGOTYPE),4,WAIT          Send passenger loads to
*                                                 GATHER statement for
*                                                 further movement to
*                                                 passenger processing
*                                                 model segment
          PRIORITY    5                           Increase priority so that
*                                                 all cargo is loaded
*                                                 before passengers
          TEST E      PF(CGOTYPE),1,RS            If palletized, fall
*                                                 through
          ENTER       DRIVER                      Seize forklift driver
```

```
          ENTER      FL10K                    Enter forklift storage
          ENTER      JI                       Seize joint inspector
          ADVANCE    RVTRI(5,PF(WTMIN),_      Inspection time
                     PF(WTMODE),PF(WTMAX))
          LEAVE      JI                       Release joint inspector
          TRANSFER   .(1000-PL(FRUST)*1000)_  Proportion are frustrated
                     ,,FINE
          ADVANCE    25,20                    Time to correct problems
 FINE     ADVANCE    2                        Move to chalk assembly
*                                             area
          ENTER      AFMARSH,PL(PALPOS)       Takes up space in Air
*                                             Force chalk assembly area
          LEAVE      FL10K                    Relese 10K-Forklift
          LEAVE      DRIVER                   Release forklift driver
          TRANSFER   ,WAIT                    Send increment to wait
*                                             for other increments
 RS       ENTER      JI                       Seize joint inspector
          ADVANCE    RVTRI(6,PF(WTMIN),_      Inspection time
                     PF(WTMODE),PF(WTMAX))
          LEAVE      JI                       Release joint inspector
          TRANSFER   .(1000-PL(FRUST)*1000)_  Proportion are frustrated
                     ,,WAIT
          ADVANCE    25,20                    Time to correct problems
 WAIT     GATHER     PF(NOINC)                Hold until all increments
*                                             are present
          TEST E     PF(ACTYPE),5,ACFT141     If increment goes on a
*                                             C-5, it falls through,
*                                             if not goes to C-141
          TEST LE    AC1,PF(DEPTIME)-210,SETUP  Determine if its load
*                                               set-up time, if not..
          ADVANCE    PF(DEPTIME)-210-AC1        Wait until load set-up
*                                               time
          TRANSFER   ,SETUP                     Send to test for cargo
*                                               type
 ACFT141  TEST LE    AC1,PF(DEPTIME)-150,SETUP  Determine if its load
*                                               set-up time, if not..
          ADVANCE    PF(DEPTIME)-150-AC1      Wait until load set-up
*                                             time
 SETUP    TEST NE    PF(CGOTYPE),4,AFPAX      Send passenger loads to
*                                             Air Force passenger
*                                             processing model segment
          TEST E     PF(CGOTYPE),1,ROLLS      If pallet or floor load,
*                                             fall through
*
 ROLLS    TERMINATE  0                        DUMMY TERMINATE BLOCK
*                                             THE MHE SELECTION SEGMENT
*                                             NEEDS TO BE ADDED
*
****************************************************************************
*          Air Force Passenger Loading Model Segment                       *
****************************************************************************
*
```

```
AFPAX     TERMINATE  0                       DUMMY TERMINATE BLOCK
*                                            THIS SECTION NEEDS TO BE
*                                            COMPLETED
***********************************************************************
*         C-141 Aircraft Loading Model Segment                        *
***********************************************************************
*
LOADC141  ENTER      ACFTC141                If a C-141 parking spot
*                                            is available, go through
          TEST NE    PF(CGOTYPE),4,PAX141    If a passenger load, send
*                                            to passenger loading
*                                            segment
          ENTER      LDTEAM                  Capture a load team
          UNLINK E   CHALKNO,CHKPAX,ALL,_    Unlink the rest of the
                     (CHALK)PF,PF(CHALK)     K-Loaders or rolling
*                                            stock on chalk
CHKPAX    TEST NE    PF(CGOTYPE),4,PAX141    If passenger load, send
*                                            to passenger loading
*                                            segment
          ENTER      PF(CHALK),2             Seize the aircraft
          PRIORITY   8                       Increase priority to 8
          ADVANCE    5,2                     Position behind aircraft
          ADVANCE    RVTRI(7,PF(LTMIN),_     Load increment on C-141
                     PF(LTMODE),PF(LTMAX))
          UNLINK E   NUMBERK,MHECHAIN,ALL,_   Release other increments
                     (NUMBRKLD)PF,PF(NUMBRKLD) from user chain, if any
          PRIORITY   PR,BUFFER                Delay increment
MHECHAIN  TEST E     PF(FIRST),1,UPLOAD1     If its the lead increment
*                                            send through
          LEAVE      PF(CHALK),2             Release C-141 for next
*                                            increment
          TRANSFER   ,MOVE                   Move to MHE release
UPLOAD1   ENTER      PF(CHALK),2             Seize the aircraft
          ADVANCE    RVTRI(8,PF(LTMIN),_     Load increment on C-141
                     PF(LTMODE),PF(LTMAX))
          LEAVE      PF(CHALK),2             Release C-141 for next
*                                            increment
          TRANSFER   ,MOVE                   Move to MHE release test
PAX141    ENTER      PF(CHALK),2             Seize the aircraft
          ADVANCE    RVTRI(8,PF(LTMIN),_     Load passengers on C-141
                     PF(LTMODE),PF(LTMAX))
          LEAVE      PF(CHALK),2             Release C-141 for next
*                                            increment
          TRANSFER   ,DONE                   Send to segment which
*                                            determines if all
*                                            increments have been
*                                            loaded on aircraft
MOVE      TEST NE    PF(CGOTYPE),2,DONE      If rolling stock, don't
*                                            need to release MHE
          GATHER     PF(NMBRLNKD)+1          Wait until all increments
*                                            for this piece of MHE
*                                            have been loaded
```

```
          TEST E      PF(FIRST),1,DONE        If its first increment,
*                                             fall through
          ADVANCE     8,2                     Time for MHE to be driven
*                                             back to staging area
          TEST E      PF(KTYPE),40,CHK25K     Test if its on a
*                                             40K-Loader
          LEAVE       KLOAD40                 Release the 40K-Loader
          LEAVE       DRIVER                  Release the MHE driver
          TRANSFER    ,DONE                   Transfer to segment to
*                                             wait on other increments
 CHK25K   TEST E      PF(KTYPE),25,REL10K     Test if its on 25K-Loader
          LEAVE       KLOAD25                 Release the 25K-Loader
          LEAVE       DRIVER                  Release the MHE driver
          TRANSFER    ,DONE                   Transfer to segment to
*                                             wait on other increments
 REL10K   LEAVE       FL10K                   Release the 10K-Forklift
          LEAVE       DRIVER                  Release the MHE driver
 DONE     GATHER      PF(NOINC)               Hold here until all
*                                             increments for chalk have
*                                             been loaded
          TEST NE     PF(INCNUMBR),1,REL141   If its not the first
*                                             increment for chalk
*                                             send through
          TERMINATE   0                       Destroy increment X-act
 REL141   TEST E      PF(CGOTYPE),4,CGOLOAD   If passengers don't need
*                                             to release load team
          LEAVE       DRIVER                  Release passenger monitor
          TRANSFER    ,BLCKOUT
 CGOLOAD  LEAVE       LDTEAM                  Release load team
 BLCKOUT  ADVANCE     20,5                    Time to get aircraft
*                                             blocked out
          LEAVE       ACFTC141                Release aircraft parking
*                                             spot and proceed to chalk
*                                             departure/terminal
*                                             complete information
*                                             output segment
*
 INFO     BPUTPIC     LINES=1,FILE=SYSPRINT,_ Prints output information
                      (PF(CHALK)),(PF(MSN)),_ to LIS file
                      (AC1),(PF(DEPTIME)-30)
OChalk ***/Mission ***, Terminal Complete ****, Scheduled TC Time ****
*
          TERMINATE   1                       Decrease termination
*                                             by one
*
***********************************************************************
*         C-5 Aircraft Loading Model Segment                          *
***********************************************************************
*
*  THIS SEGMENT MUST BE COMPLETED IN ORDER TO MODEL THE FULL DEPLOYMENT
*
***********************************************************************
```

```
*          Run-Control Statements                                                    *
***************************************************************************
*
           START      51                                   Run model until the 51
*                                                          airdrop chalks have
*                                                          departed (WILL NEED TO
*                                                          INCREASE TO TOTAL NUMBER
*                                                          OF MISSIONS FOR FULL
*                                                          SCALE MODEL USE)
           END                                             End model execution
*
*
*   WHEN RUNNING FULL SCALE EXPERIMENTATION, CONTROL LOGIC WILL NEED TO
*   BE ADDED TO GET THE DESIRED NUMBER OF REPLICATIONS
```

Appendix E: "LDINFO" File

MASTER CHALK INFORMATION FILE
(SAVED UNDER A:LDINFO.TXT)

The 1st column contains the chalk number, the 2nd column contains the mission number, the 3rd column contains the number of increments on chalk, the 4th column contains the aircraft departure time (in absolute computer clock time), the 5th column contains the branch of service for mission (100=Air Force, 300=Army), and the 6th column contains the aircraft type for the chalk

** These comments need to be deleted for actual model runs

** For the sensitivity analysis experimentation this file was reduced to chalks 8 through 58 since they were the only airdrop cargo chalks

```
001 076 01 1145 100 141
002 077 08 1150 300 141
003 078 08 1180 300 141
004 074 36 1195 100 005
005 075 30 1200 100 005
006 079 06 1210 300 141
007 080 07 1240 300 141
008 051 01 1755 300 141
009 050 02 1765 300 141
010 049 02 1775 300 141
011 048 02 1785 300 141
012 047 04 1795 300 141
013 046 04 1805 300 141
014 045 02 1815 300 141
015 044 02 1825 300 141
016 043 02 1835 300 141
017 042 04 1845 300 141
018 041 04 1855 300 141
019 040 04 1865 300 141
020 039 04 1875 300 141
021 038 04 1885 300 141
022 037 04 1895 300 141
023 036 04 1905 300 141
024 035 04 1915 300 141
025 034 04 1925 300 141
026 033 04 1935 300 141
027 032 04 1945 300 141
028 031 04 1955 300 141
029 030 04 1965 300 141
030 029 04 1975 300 141
031 028 04 1985 300 141
032 027 03 1995 300 141
```

033	026	04	2005	300	141
034	025	04	2015	300	141
035	024	04	2025	300	141
036	023	04	2035	300	141
037	022	04	2045	300	141
038	021	04	2055	300	141
039	020	04	2065	300	141
040	019	04	2075	300	141
041	018	04	2085	300	141
042	017	04	2095	300	141
043	016	04	2105	300	141
044	015	04	2115	300	141
045	014	03	2125	300	141
046	013	04	2135	300	141
047	012	04	2145	300	141
048	011	04	2155	300	141
049	010	04	2165	300	141
050	009	04	2175	300	141
051	008	04	2185	300	141
052	007	04	2195	300	141
053	006	04	2205	300	141
054	005	04	2215	300	141
055	004	04	2225	300	141
056	003	28	2235	300	141
057	002	28	2245	300	141
058	001	28	2255	300	141
059	073	01	2965	300	141
060	072	01	2965	300	141
061	071	01	2965	300	141
062	070	01	2965	300	141
063	069	01	2965	300	141
064	068	01	2965	300	141
065	067	01	2965	300	141
066	066	01	2965	300	141
067	065	01	2965	300	141
068	064	01	2965	300	141
069	063	01	2965	300	141
070	062	01	2965	300	141
071	061	01	2965	300	141
072	060	01	2965	300	141
073	059	01	2965	300	141
074	058	01	2965	300	141
075	057	01	2965	300	141
076	056	01	2965	300	141
077	055	01	2965	300	141
078	054	01	2965	300	141
079	053	01	2965	300	141
080	052	01	2965	300	141
081	104	07	3105	300	141
082	200	09	3110	300	141
083	201	10	3115	300	141
084	202	09	3120	300	141

085	203	09	3150	300	141
086	100	15	3160	300	005
087	102	15	3190	300	005
088	103	15	3220	300	005
089	105	06	3235	300	141
090	204	09	3240	300	141
091	205	05	3245	300	141
092	206	05	3250	300	141
093	106	07	3265	300	141
094	107	07	3295	300	141
095	207	05	3300	300	141
096	208	05	3305	300	141
097	108	06	3325	300	141
098	209	05	3330	300	141
099	109	07	3355	300	141
100	210	05	3360	300	141
101	110	07	3385	300	141
102	211	06	3390	300	141
103	212	06	3400	300	141
104	213	06	3430	300	141
105	101	10	3435	300	005
106	111	07	3450	300	141
107	214	10	3455	300	141
108	215	02	3460	300	141
109	112	06	3480	300	141
110	216	06	3490	300	141
111	113	06	3510	300	141
112	217	11	3520	300	141
113	218	09	3525	300	141
114	114	07	3540	300	141
115	115	09	3570	300	141
116	219	11	3575	300	141
117	220	11	3580	300	141
118	221	11	3585	300	141
119	222	09	3590	300	141
120	116	09	3600	300	141
121	117	09	3630	300	141
122	223	11	3635	300	141
123	224	11	3645	300	141
124	400	15	3720	100	005
125	500	19	3765	100	005
126	501	18	3775	100	005
127	403	07	3855	100	141
128	406	11	3870	100	141
129	300	08	4695	300	005
130	401	33	4725	100	005
131	402	21	4770	100	005
132	404	20	4810	100	005
133	405	22	5025	100	005

Appendix F: "LDPLANS" File

LOAD PLAN INFORMATION FILE
(SAVED AS A:LDPLANS.TXT)

This trace file is used to assign increment type codes to X-acts coming out of the SPLIT block in the model. This file is arranged as follows:

The 1st column contains the increment number for that particular increment within the chalk, the 2nd column contains the increment type code (corresponds with the first column in PROCTYM.TXT matrix data file), and the 3rd column contains the chalk number (this column is not read by the computer, its there to aid in building and trouble shooting the file).

** These comments need to be deleted before this trace file can be used to run the model.

** For the sensitivity experimentation this file was reduced to chalks 8 through 58 since they were the only airdrop cargo loads

```
01 058        001
01 042        002
02 042
03 016
04 016
05 016
06 016
07 022
08 061
01 042        003
02 042
03 016
04 016
05 016
06 016
07 020
08 061
01 042        004
02 042
03 042
04 042
05 042
06 042
07 042
08 042
09 042
10 042
11 042
```

12	042	
13	042	
14	042	
15	042	
16	042	
17	042	
18	042	
19	042	
20	064	
21	065	
22	066	
23	063	
24	063	
25	016	
26	067	
27	068	
28	069	
29	069	
30	069	
31	069	
32	069	
33	069	
34	069	
35	069	
36	059	
01	042	005
02	042	
03	042	
04	042	
05	042	
06	042	
07	042	
08	042	
09	042	
10	042	
11	042	
12	042	
13	042	
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15	070	
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17	072	
18	072	
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21	072	
22	072	
23	069	
24	069	
25	069	
26	069	
27	069	

28	069	
29	069	
30	059	
01	024	006
02	019	
03	019	
04	019	
05	019	
06	061	
01	016	007
02	016	
03	016	
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01	005	015
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01	057	016
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01	003	017
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01	007	018
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01	007	019
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01	007	020
02	007	
03	008	

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04	008	
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02	007	
03	008	
04	008	
01	003	023
02	003	
03	003	
04	003	
01	007	024
02	007	
03	008	
04	008	
01	007	025
02	007	
03	009	
04	009	
01	010	026
02	010	
03	010	
04	003	
01	010	027
02	010	
03	010	
04	003	
01	010	028
02	010	
03	010	
04	003	
01	010	029
02	010	
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04	003	
01	011	030
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03	011	
04	003	
01	003	031
02	003	
03	003	
04	003	
01	012	032
02	013	
03	003	
01	003	033
02	003	
03	003	
04	003	

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03	003	
04	003	
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02	003	
03	003	
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02	003	
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04	003	
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08	016	

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05	027	
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03	016	

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09	031	
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07	061	
01	016	107
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06	061	
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05	021	
06	021	
07	021	

08	021	
09	021	
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09	073	
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04	077	
05	075	
06	075	
07	074	
08	074	
09	074	
10	042	
11	042	
12	071	
13	078	

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18	081	
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03	082	
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05	082	
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07	042	
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09	089	
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03	043	
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05	031	
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08	031	
01	087	130
02	087	

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04	087	
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06	078	
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06	063	
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12	098	
13	090	
14	090	
15	083	
16	079	
17	101	
18	042	
19	042	
20	042	
21	042	
22	059	

Appendix G: "PROCTYM" File

DEPLOYMENT MODEL
INCREMENT TYPE MATRIX FILE

The 1st column contains increment type code number, 2nd column contains increment weight, the 3rd column contains number of pallet positions occupied by increment, the 4th column contains minimum scale times, the 5th column contains maximum scale times, the 6th column contains mode scale times, the 7th column contains minimum loading times, the 8th column contains maximum loading times, the 9th column contains mode loading times, the 10th column contains cargo or load type (1=pallet, 2=rolling stock, 3=airdrop, and 4=passengers), the 11th column contains frustration probability, and the 12th column, which is not read by the computer, contains the increment type description (AD=airdrop, R/S= rolling stock, PLT=pallet, and F/L=floor load)

* When running this file in the model, these comments need to be deleted

001	38500	3.9	032	053	045	010	025	017	3	000	M-551 Sheridan Tnk (AD)
002	04000	1.1	002	008	006	004	008	006	3	000	8' MASS (AD)
003	10500	2.4	006	031	011	003	024	009	3	000	M-998 GP HMMWV (AD)
004	38200	3.8	011	026	017	008	017	012	3	000	950-B Loader (AD)
005	37000	4.3	010	026	018	010	017	014	3	000	130-G Grader (AD)
006	06250	1.9	006	012	009	004	009	006	3	000	13-Wheel Roller (AD)
007	10500	2.4	006	022	012	003	024	009	3	000	M-1038 GPW HMMWV (AD)
008	09000	2.5	006	022	012	003	024	009	3	000	M-102 105MM How (AD)
009	06500	1.9	003	015	008	003	011	006	3	000	M-101 Trailer (AD)
010	10500	2.4	006	022	012	005	011	008	3	000	M-966 TOW HMMWV (AD)
011	10500	2.4	006	022	011	003	024	009	3	000	M-1025 Arm HMMWV (AD)
012	21060	3.7	006	012	010	006	017	011	3	000	M-35 2.5 Ton Truck (AD)
013	08080	1.9	006	022	012	005	011	008	3	000	M-105 1.25T Trlr (AD)
014	10500	3.0	006	022	012	005	011	008	3	000	M-996 Ambulance (AD)
015	01295	0.3	001	004	002	001	005	002	3	000	CDS Bundle (AD)
016	06000	2.1	003	015	008	005	015	010	2	005	M-998 GP HMMWV (R/S)
017	06000	1.9	003	015	008	005	015	010	2	005	M-105 1.25T Trlr (R/S)
018	08000	2.3	003	015	008	005	015	010	2	005	M-996 Ambulance (R/S)
019	08000	2.2	003	015	008	005	015	010	2	005	M-1038 GPW HMMWV (R/S)
020	07400	2.0	003	015	008	005	015	010	2	005	M-966 TOW HMMWV (R/S)
021	06000	1.0	002	012	006	001	010	005	1	007	Explosive 463L (PLT)
022	07000	2.1	003	015	008	005	015	010	2	005	M-1025 Arm HMMWV (R/S)
023	06000	2.2	003	015	008	005	015	010	2	005	M-1037 (R/S)
024	15000	3.0	005	025	012	007	025	014	2	007	M-35 2.5 Ton Truck (R/S)
025	35000	3.6	005	025	012	007	025	014	2	007	M-923 ROWPU (R/S)
026	50000	2.2	003	015	008	005	015	010	2	005	M-936 Wrecker (R/S)
027	04000	2.1	003	015	008	005	015	010	2	005	M-167 Vulcan (R/S)
028	35000	2.8	004	017	010	006	017	012	2	006	M-551 Sheridan Tnk (R/S)
029	08000	7.2	010	030	020	015	045	030	2	005	AH-1S Helicopter (R/S)
030	03000	2.4	007	025	018	010	038	022	2	005	OH-58 Helicopter (R/S)

031	14000	5.6	010	030	020	015	045	030	2	005	UH-60 Helicopter (R/S)
032	35000	3.8	005	025	012	007	025	014	2	007	130-G Grader (R/S)
033	35000	2.4	005	025	012	007	025	014	2	007	D-5B Bulldozer (R/S)
034	35000	3.4	005	025	012	007	025	014	2	007	950-B Loader (R/S)
035	02400	3.0	003	015	008	005	015	010	2	005	M-342 2.5Ton D-Trk (R/S)
036	29000	4.3	005	025	012	007	025	014	2	007	M-817 5Ton D-Truck (R/S)
037	00000	000	000	000	000	000	000	000	0	000	210CFM Air Comp (R/S)
038	00000	000	000	000	000	000	000	000	0	000	13-Wheel Roller (R/S)
039	00000	000	000	000	000	000	000	000	0	000	15T Tilt Trailer (R/S)
040	28000	3.0	005	025	012	007	025	014	2	007	6K-RT Forklift (R/S)
041	28000	3.1	005	025	012	007	025	014	2	007	10K-RT Forklift (R/S)
042	04500	1.0	002	012	006	001	010	005	1	007	463L Pallet (PLT)
043	20000	3.1	003	015	008	005	015	010	2	005	M-146 Shelter (R/S)
044	00000	000	000	000	000	000	000	000	0	000	M-147 Shelter (R/S)
045	00000	000	000	000	000	000	000	000	0	000	S250 Shelter (R/S)
046	00000	000	000	000	000	000	000	000	0	000	AGPU Power Supply (R/S)
047	00000	000	000	000	000	000	000	000	0	000	A-90 Shop Set (R/S)
048	00000	000	000	000	000	000	000	000	0	000	GRC-206 (R/S)
049	08800	2.5	003	015	008	005	015	010	2	005	M-1008 Truck (R/S)
050	06400	2.1	003	015	008	005	015	010	2	005	M-1009 Truck (R/S)
051	23700	3.2	005	025	012	007	025	014	2	007	10K-AT Forklift (R/S)
052	00000	000	000	000	000	000	000	000	0	000	13K-AT Forklift (R/S)
053	23000	2.5	005	025	012	007	025	014	2	006	10K-STD Forklift (R/S)
054	22540	3.7	010	035	028	020	055	035	2	004	25K-Loader (R/S)
055	24340	3.3	010	035	028	020	055	035	2	004	25K-TAC Loader (R/S)
056	00000	000	000	000	000	000	000	000	0	000	40K-Loader (R/S)
057	37100	3.5	011	020	015	007	014	010	3	000	D-5B Bulldozer (AD)
058	00000	0.0	000	000	000	055	072	063	4	005	100 Passengers
059	00000	0.0	000	000	000	045	065	055	4	004	75 Passengers
060	00000	0.0	000	000	000	030	045	038	4	003	50 Passengers
061	00000	0.0	000	000	000	020	030	026	4	002	25 Passengers
062	00000	0.0	000	000	000	008	016	012	4	001	10 Passengers
063	01500	1.2	003	015	007	003	010	006	2	005	NF-2 Light Cart (R/S)
064	01100	1.0	003	015	007	003	010	006	2	007	LOX Tank (R/S)
065	00320	0.6	003	015	007	003	010	006	2	005	Hydraulic Cart (R/S)
066	02100	0.9	003	015	007	003	010	006	2	004	MC-1A Compressor (R/S)
067	00360	1.0	001	004	002	002	003	004	1	001	A-10 Towbar (F/L)
068	02860	3.4	005	025	012	007	025	014	2	005	Tank Loader (R/S)
069	00200	0.2	001	004	002	001	003	002	1	006	Nesting Box (F/L)
070	10668	2.3	005	025	012	007	025	014	2	006	MHU-110 Trailer (R/S)
071	05920	1.9	003	015	008	005	015	010	2	005	Bobtail Jeep (R/S)
072	03355	1.8	003	015	008	005	015	010	2	007	Acft Engine Trlr (R/S)
073	11010	1.7	003	015	008	005	015	010	2	005	6K-STD Forklift (R/S)
074	06760	2.0	003	015	008	005	015	010	2	005	MHU-83 Bomb Lift (R/S)
075	02940	2.4	003	015	008	005	015	010	2	005	Ammo Loading Sys (R/S)
076	10800	1.9	005	025	012	007	025	014	2	006	MB-4 Tug (R/S)
077	02800	2.2	003	015	008	005	015	010	2	005	GFU-7/E (R/S)
078	00790	1.0	003	015	007	003	010	006	2	004	MC-2 (R/S)
079	00900	0.8	003	015	007	003	010	006	2	004	Heater Duct (R/S)
080	06760	2.0	003	015	008	005	015	010	2	005	MJ-1A Bomb Lift (R/S)
081	02100	1.4	003	015	007	003	010	006	2	004	TF-1 Light All (R/S)
082	04000	1.6	003	015	008	005	015	010	2	005	MHU-141 Trailer (R/S)

083	05600	1.1	003	015	008	005	015	010	2	005	-86 Generator (R/S)
084	05240	1.4	003	015	008	005	015	010	2	005	MJ-2A Mule (R/S)
085	06750	2.8	003	015	008	005	015	010	2	005	6 Pack Truck (R/S)
086	01740	1.1	003	015	008	005	015	010	2	005	Water Wash Cart (R/S)
087	00325	0.2	001	004	002	001	003	002	1	004	Fire Extinguisher (F/L)
088	05960	1.1	003	015	008	005	015	010	2	005	Generator Set 400 (R/S)
089	07335	1.9	003	015	008	005	015	010	2	005	Bobtail Tractor (R/S)
090	02150	2.1	002	008	005	003	011	008	2	003	B-1 Maint Stand (R/S)
091	01220	0.9	003	015	008	005	015	010	2	005	MA-1A Power Unit (R/S)
092	00400	1.0	001	004	002	002	003	004	1	001	C-130 Towbar (F/L)
093	04525	1.7	003	015	008	005	015	010	2	007	Dolly w/engine (R/S)
094	01350	0.5	002	008	005	003	011	008	1	004	Engine Change Cart (R/S)
095	03280	1.5	003	015	007	003	010	006	2	007	Nitro Trailer (R/S)
096	03480	1.5	003	015	008	005	015	010	2	005	-60 Generator (R/S)
097	02615	1.8	003	015	008	005	015	010	2	005	3000 Trailer (R/S)
098	00560	1.1	002	008	005	003	011	008	1	003	B-4 Maint Stand (R/S)
099	05810	1.7	003	015	008	005	015	010	2	005	12M Trailer EWS (R/S)
100	16060	3.0	005	018	010	003	011	005	1	004	3 Pallet Train (PLT)
101	00280	0.4	001	004	002	001	003	002	1	006	External Tester (F/L)
102	02880	1.2	002	008	005	003	011	008	2	003	Cabin Press Tstr (R/S)
103	00980	1.1	002	008	005	003	011	008	2	003	De-icing Cart (R/S)
104	02000	1.6	002	008	005	003	011	008	2	003	Fuel Tank FM (R/S)
105	02475	1.4	002	008	005	003	011	008	2	003	MC-7 Compressor (R/S)
106	00360	1.0	001	004	002	002	003	004	1	001	Nosewheel Towbar (F/L)
107	02800	1.7	003	015	008	005	015	010	2	005	M-101 Trailer (R/S)
108	03160	2.6	005	025	012	007	025	014	2	006	M-102 105MM How (R/S)

Bibliography

Air Force Center for Studies and Analyses. Catalog of Computer Simulation Tools Used by the United States Air Force Center for Studies and Analyses. Washington: AFCSA/SAMS, August 1988.

Balci, Osman. "How to Assess the Acceptability and Credibility of Simulation Results," Proceedings of the 1989 Winter Simulation Conference. 62-71. New Jersey: IEEE Press, 1989.

Banks, Jerry and John S. Carson, II. Discrete-Event System Simulation. Englewood Cliffs NJ: Prentice-Hall, 1984.

Battilega, John A. and Judith K. Grange. The Military Applications of Modeling. Wright-Patterson Air Force Base OH: Air Force Institute of Technology Press, 1978.

Bird, Julie, "AF-Army Team Set Up for Forcible Entry," Air Force Times, 26 October 1992: 14-18.

Boatright, Rodney L. "Combat Support Doctrine: Where We've Been, Where We Are, and Where We Should Be Going." Air Force Journal of Logistics, 17: 14-17 (Summer 1992).

Bobillier, P.A., B.C. Kahan, and A.R. Probst. Simulation With GPSS and GPSS V. Englewood Cliffs NJ: Prentice-Hall, 1976.

Christensen, Maj Thomas W. and Capt Gerald L. White. Aerial Port of Embarkation Capability Planning: Volume One. MS thesis, AFIT/LSH. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1983 (AD-A134433).

Coker, SMSgt Daniel J. Superintendent, 463L Material Handling Equipment, Transportation Plans and Programs, Headquarters, Air Mobility Command (HQ AMC/XOPE), Scott AFB IL. Personal interview. 15 January 93.

Comstock, Col Phil. Headquarters Air Combat Command (ACC) Action Officer. "Ft Bragg/Pope AFB Simultaneous Deployment Review." Briefing to the Commanders of Air Combat Command (USAF) and Army Training and Doctrine Command (USA). HQ ACC, Langley AFB VA, 1 June 1992.

Dalton, Maj Kathy. Chief, Transportation Training, Headquarters Air Mobility Command, Scott AFB IL. Telephone interview. 20 October 1992.

Department of the Air Force. Basic Aerospace Doctrine of the United States Air Force. AFM 1-1. HQ USAF, March 1992.

Department of the Air Force. Movements of Units in Air Force Aircraft. AFR 76-6. Washington: HQ USAF, 10 November 1989.

Department of the Air Force. USAF Mobility Planning. AFR 28-4. Washington: HQ USAF, 27 March 1987.

"Desert Shield Joint Committee Report." Report to CINCTRANS and CINCFOR, Scott AFB IL, 7 December 1990.

Dietz, John. Analyst, Logistics Management Agency, Maxwell AFB (Gunther Annex) AL. Telephone interview. 20 October 1992.

Eisenberg, Maj Jeff P. Operations Officer, 3d Aerial Port Squadron, Pope AFB NC. Telephone interview. 2 October 1992.

Fredette, Capt Michael R. Estimating Material Handling Equipment (MHE) and Manpower Requirements for an Air Freight Ramp Operation Using SLAM II. MS thesis, AFIT/GLM/LSM/86S-24. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1986 (AD-A174430).

Head, Lt Col John. Chief, Transportation Plans and Programs (XOPP), Headquarters Air Mobility Command, Scott AFB IL. Telephone interview. 5 October 1992.

HQ USAF. "CAS: The Mission of Choice." Policy Letter from the Office of the Secretary of the Air Force. February 1992.

Hughes, Wayne P., Jr. Military Modeling. Washington: The Military Operations Research Society, 1984.

Kelton, David W. and Averill M. Law. Simulation Modeling and Analysis. New York: McGraw-Hill, 1982.

Liggett, Capt James K. A Model of STAMP/STRAPP Deployment at Kelly AFB Texas. MS thesis, AFIT/GLM/LSC/89S-38. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1989 (AD-B138827).

McLeod, John. Computer Modeling and Simulation: Principles of Good Practice. La Jolla CA: Simulation Councils, 1982.

Miller, Lt Col Charles E. Airlift Doctrine. Maxwell AFB AL: Air University Press, 1988.

Neelamkavil, Francis. Computer Simulation and Modeling. New York: John Wiley & Sons, 1987.

Phillips, CMSgt Douglas R. Operations Superintendent, 3rd Aerial Port Squadron, Pope AFB NC. Personal interview. 19 March 1993.

Phillips, CMSgt Douglas R. Operations Superintendent, 3rd Aerial Port Squadron, Pope AFB NC. Telephone interview. 16 June 1993.

Pignatiello, Joseph J. and Rosemary H. Wild. "An Experimental Design Strategy for Designing Robust Systems Using Discrete-Event Simulation," Simulation, 57: 358-368 (December 1991).

Plans, Policy, and Programming, Forces Command. Memorandum for the Directorate of Plans, Policy, and Programming, J5. Fort McPherson GA, 1 July 1992.

Reusche, Capt Michael A. and Capt Vaughn D. Wasem. Simulation and Manpower Forecasting Models for Tactical Aerial Port Operations In a Contingency Environment. MS thesis, AFIT/LSH. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, September 1982 (AD-A122846).

Rogers, TSgt Hansel E. Training Noncommissioned Officer, Terminal Services, 3rd Aerial Port Squadron, Pope AFB NC. Personal interview. 20 March 1993.

Sadowski, Randall P. "The Simulation Process: Avoiding the Problems and Pitfalls," Proceedings of the 1989 Winter Simulation Conference. 72-79. New Jersey: IEEE Press, 1989.

Sargent, Robert G. "Simulation Model Verification and Validation," Proceedings of the 1991 Winter Simulation Conference. 37-47. New Jersey: IEEE Press, 1991.

Schenk, Steven M. "Forecasting and Modeling Using PC-Based Software: A Challenge and an Opportunity for Professional Logisticians," Air Force Journal of Logistics: 32-34 (Winter 1992).

Schriber, Thomas J. An Introduction to Simulation Using GPSS/H. New York: John Wiley & Sons, 1991.

Training and Doctrine Command and Air Combat Command. "CCW: Integrated Operations Concept for Corp Elements and Airland Operations Wings." Coordinating Draft (TRADOC PAM XX-XX and ACCP 50-XX). May 1992.

Whitrock, Col Charles. Commander, 624th Airlift Group. "Pope AFB Airlift Support." Briefing to the XVIII Corps Commander. Headquarters 624th Airlift Group, Pope AFB NC, 22 October 1992.

Williams, Capt Layton E. Chief, Plans, Resources, and Mobility, Pope AFB NC. Telephone interview. 16 December 1992.

Young, Maj Drew M. Ground Liaison Officer, Pope AFB NC. Telephone interview. 20 March 1993.

Vita

Captain John B. Prechtel was born on 31 January 1962 in Terre Haute, Indiana. He graduated from North Central High School in Farmersburg, Indiana in 1980. He then attended Indiana State University, graduating in May 1985 with a Bachelor of Science degree in Manufacturing Technology. In June 1987, he received his commission. He was then assigned to the Directorate of Distribution at McClellan AFB, California as the Assistant Air Terminal Manager. In March 1989, he was transferred to the 6th Aerial Port Squadron at Howard AB, Panama, where he served as Aerial Port Duty Officer. He was put in charge of the Passenger Terminal during Operation JUST CAUSE in December 1989 and he helped coordinate the redeployment of U.S. forces after the invasion. In June 1990, he was reassigned to the 3rd Mobile Aerial Port Squadron at Pope AFB, North Carolina. In early August 1990, he deployed with the squadron to Southwest Asia in support of Operation DESERT SHIELD. At the deployed location Captain Prechtel served as Duty Officer and Operations Officer. After 7 1/2 months in the Arabian Peninsula, he returned to Pope as the OIC of Plans and Mobility. He then attended Squadron Officer's School enroute to entering the Air Force Institute of Technology in May of 1992.

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Vita

Captain Mark S. Wingreen was born on 23 June 1959 in Racine, Wisconsin. He graduated from Burlington High School in Burlington, Wisconsin in 1977 and attended the University of Wisconsin at Whitewater, graduating cum laude with a Baccalaureate degree (B.S.) in Mathematics in May of 1985. In June 1987, he received an Air Force commission and was subsequently assigned to the 831st Transportation Squadron at George Air Force Base, California. First, as the Vehicle Operations Officer, he was responsible for 45 military and civilian personnel and the management of a vehicle fleet valued in excess of $10 million. Next, he served as OIC, Plans, Programs, and Mobility before reassignment to the 316th Aerial Port Squadron at Yokota Air Base, Japan in July 1989. There, he served briefly as an Air Terminal Operations Center Duty Officer before becoming the OIC of the largest Passenger Service operation in the Pacific theater. In January 1991, Captain Wingreen became Chief of Plans, Resources, and Mobility, and was also chosen by the wing commander to augment the 374th Tactical Airlift Wing as his executive officer. For the next six months, Captain Wingreen fulfilled the duties of both positions. He entered the Air Force Institute of Technology in May of 1992.

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13. ABSTRACT *(Maximum 200 words)*

This thesis produced a model of the Army airdrop segment of the Pope AFB deployment system. The original intent was to model the entire system and simulate the simultaneous deployment of the 23rd Wing and 82nd Airborne Division; however, time constraints and incomplete data forced a reduction in scope. The study provides an excellent foundation for further research into the use of simulation to develop a generalized deployment sizing model. The airdrop segment of the system was modeled using the researcher's personal observations of the system, the expertise of personnel who work within the system, and documentation of the problems and lessons learned during past large-scale deployments. The parameters determined to significantly affect system performance were modeled; those that didn't, were not. The conceptual model was validated through comparison of the conceptual model and the actual system with air transportation experts at Pope AFB. The coded model was then verified through numerous runs in test mode where coded logic was iteratively refined and sensitivity analysis that determined the model behaved as expected.

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